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"FOR BETTER SCIENCE TEACHING"

The Science Counselor

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Electronic Brains

• By A. W. Duerig
PLANT EXTENSION ENGINEER, BELL TELEPHONE COMPANY OF PENNSYLVANIA

This is a talk presented on April 11, 1959, at the Annual Meeting of the Pennsylvania Catholic Round Table of Science at Immaculata College, Immaculata, Pennsylvania.

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We're living in an age of scientific marvels. Almost any day you can see evidence of this in the newspapers—newer and bigger satellites, miracle drugs, nuclear energy used for more and more applications, energy directly from the sun used to produce electricity, rockets reaching toward the moon and beyond, and many other things that seemed fantastic only a few years ago.

The brains and the efforts of many topnotch scientists are behind all these achievements, but most of these things would not be possible without the aid of another type of brain. We often call these, "electronic brains." What are these "electronic brains" that we've all heard so much about? How do they work and what do they do, anyway? Engineers have spent years obtaining answers to these questions, but I hope to give here in a short time at least an idea of the principles that are involved.

Back in November 1950, we had a hurricane along the East Coast. This was back before we started using girls' names to designate hurricanes so I can't tell what the name of this one was, but anyway, it did quite a bit of damage. Mainly because we didn't see it coming. The reason we didn't see it is that it was hidden behind a great deal of detail. Weather prediction depends on the careful analysis of tremendous amounts of information which is constantly being collected and forwarded to the Weather Bureau. This mass of data holds all the right answers for weather forecasting, but there's just too much of it for humans to go through in time. It would have taken the weather people more than six months to forecast the 1950 storm on the basis of the information they had available the day before it hit. However, a few years ago, that same mass of information was fed into a large electronic brain, and in less time than it takes to button up your overcoat, the machine had accurately forecast the path of the storm, its rate of speed, the velocity of its wind, and so on. Naturally, this was too late to do the people who were caught in the storm any good, but it did prove the machine's ability to do this same kind of atmospheric crystal gazing for future storms.

FIGURE 1

These electronic brains or computers are being used in the business field to figure payrolls and inventories, to calculate and send out bills, to keep track of complex business operations, and to analyze these operations for short cuts to save money. They're used by scientists to analyze data sent back from satellites, to solve complicated mathematical problems, to compute astronomical data, and to determine in advance the performance that we should expect from newly-designed jet planes, transistors, radars, etc. Computers are used to guide rockets in their flight; to aim guns, taking into account all the things that affect trajectory such as wind, temperature, movement of the target, and the earth's rotation. There are plans to use computers for medical diagnosis, for scientific research, and for many almost unbelievable applications. In my own field, computers direct the setting up of the telephone calls you dial and record the information needed to bill you for them. And, in a lighter vein, computers have been built to play tic-tac-toe and even a fairly respectable game of chess.

There are two main categories of computers: The first of these functions on the basis of continuous input information which is data that varies smoothly from one value to another. This type of computer is called an analog computer, and a simple sample of it would be an ordinary slide rule. A somewhat more complex example would be the differential analyzers that have been used in some of our universities to solve mathematical equations. The second type of computer functions on the basis of data that varies from one value to another in discrete steps. In this category, we have simple adding machines, or some of these large electronic brains that we have been talking about. The remainder of our discussion today is going to be about the second type—the digital computer—since it is in this field that most of the current advances in computer technology are taking place.

You've heard of many things attributed to electronic brains. Some of these things are fact and some, so far at least, are still science fiction. As of now a computer can:

1. Learn what it's told and remember it,
2. Add and substract—in fact, solve any mathematical problem,
3. Check its own work and report errors,
4. Learn from experience,

5. Diagnose its own troubles and correct them to some extent,
6. Reproduce itself. (Computers have been used to design other computers.)

Of course, not all computers can do all of these things. Some things none of them can do yet are

1. Understand speech,
2. React instinctively to situations,
3. Think creatively or use judgment.

These are a lot of words you may say, but what we really want to know is, can these electronic brains think? A simple question. Can a mass of tubes and transistors and wires and what-not actually think? The answer is not so simple. It depends on what we mean by thinking. If by "thinking" we mean creative thought and imagination such as our forefathers used when they wrote our Constitution, the answer to whether the computer can think is "No". If by "thinking" we mean the process we go through if we decide to go for a ride in the country just on an impulse because it might be fun, the answer is again "No". But if by "thinking" we mean remembering a lot of facts and using these facts to solve problems and make logical decisions based on them, then the computer *can* think and can do it a whole lot better and faster than you or I.

Let me use another example. Let's say you want to make a telephone call and you don't have dial service. The operator will ring the one telephone you want to reach out of all the millions of telephones. She'll prepare a slip of paper for accounting purposes and record the telephone number that you called and your own number. She'll enter the date, the time you started talking, and the time you finished. Later, she'll compute the length of the call. In performing these operations, we all agree that the operator is thinking. However, our new automatic dial systems will do all of these things I've mentioned without human intervention and do them at least equally well or better. They will select the proper telephone, make out all the records concerning the calling and the called numbers, and compute the length of the call. This is all done with machinery. Should we then say the machine is thinking?

Computer Language

I'd like to discuss two aspects of these electronic brains: First, the language they use and, second, how they do their thinking. First, let's talk about the language the computers use. We've all been brought up to do our arithmetic in the decimal numbering system. We use ten different symbols to represent numbers: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9, and by combining these in various ways, we can express any number as high as you please still using only these ten symbols. If I write the number **4687** you know right away from the positions of the digits that what I mean is 7 units, 8 tens, 6 hundreds, and 4 thousands.

Computers don't use our decimal numbering system in their inner workings. Instead, they use what is called the binary numbering system. In order to understand computers, we should know something about this binary system. Rather than 10 digits it has only 2. We call these *one* and *zero*. Digits have place values, but instead of units, tens, hundreds, and thousands they carry place values of units, twos, fours, sixteens, and so on. To state this somewhat more mathematically, the decimal system is based on powers of ten, and the binary system is based on powers of 2.

We use decimal numbers, and our computers use binary numbers—so we have a language problem. This calls for a translator and I'd like to show how we can translate between these two systems.

Figure I is an electronic translator. It will change deci-

16	20	24	28
17	21	25	29
18	22	26	30
19	23	27	31

CARD I

8	12	24	28
9	13	25	29
10	14	26	30
11	15	27	31

CARD II

4	12	20	28
5	13	21	29
6	14	22	30
7	15	23	31

CARD III

2	10	18	26
3	11	19	27
6	14	22	30
7	15	23	31

CARD IV

1	9	17	25
3	11	19	27
5	13	21	29
7	15	23	31

CARD V

1. Have a person think of a number between 1 and 31.
2. Show him the five cards one at a time and have him tell you on which cards his number appears.
3. To find the number, add up mentally the upper left corner numbers of the cards containing the selected number. Note these numbers are powers of two, *e.g.*, $16 = 2^4$, $8 = 2^3$, $4 = 2^2$, $2 = 2^1$, $1 = 2^0$.

The numbers appearing on the cards are our familiar decimal numbers. You however, have used the principles of the binary number system to find the secret number. Most modern day computers and telephone switching systems use binary numbers to perform their work. It is interesting to realize that with 10 cards you could have identified one out of 1024 numbers. With 20 cards, you could have identified one out of over a million numbers.

FIGURE 2

ARITHMETIC NUMBER GAME

mal numbers into binary numbers. With the switch at the lower left I can set up a decimal number—in this case, three, on the tube at the lower center of the translator. The rectangular matrix of semi-conductor diodes just above this translates this decimal number into a binary number, which is shown on the four lamps at the top of the translator. We'll say that light *on* represents a binary *one* and light *off* is a *zero;* since the two lights on the right are illuminated, we can see that the binary equivalent of three is 0011. Remembering that binary digits represent powers of two, we can see readily that this is correct since we have a binary one in the units and the two's places, and one plus two make three. With this translator we can change any other decimal digit between zero and nine to its binary equivalent. This, then, is an electronic translator capable of changing the *decimal numbers* with which we're familiar into *binary numbers* which computers can handle. Translators just like this are used in most of our computing systems. I'd like to point out one thing that's rather obvious: binary numbers are longer than their decimal equivalents. It takes anywhere from one to four binary digits to express numbers between 0 and 9, all of which we can express with just one digit in the decimal system. This is one slight disadvantage of the binary numbering system, but it's more than offset by several advantages.

That's half of our translation problem. When the computer finishes working on these binary numbers, it has to convert them back to the decimal system for our use. Let me show you how binary to decimal translation works by playing a little game. I'm going to ask you to think of a number between zero and 31. Then by asking you five questions, each of which can be answered simply "yes" or "no", I'll attempt to find out what your number is. (Figure 2). Now this isn't magic. Engineers, unfortunately, aren't magicians; our jobs would often be easier if we were. Let's play the game once more, and I'll show you this time how it's done. When I ask if your number is on these cards, each time I get a "yes" answer I'll write a one and each time I get a "no" answer I'll write a zero. (For example, if the number 23 is selected, the binary number produced by the above operation will be 10111 resulting from a "yes" or "no" answer and then three "yes" answers. Our binary place values from left to right are 16, 8, 4, 2, and 1. We add the place values where we have ones and get our decimal equivalent, namely 23.) Notice that by asking five questions, I could identify one out of 32 objects. With six questions, I would have picked one out of 64. With ten questions one out of over a thousand, and if I were permitted 20 questions as in the popular game, I could identify one out of over a million items. As you can see, we can get to high numbers rather quickly with powers of two. An often told story that illustrates this tells of a knight who saved a princess from the clutches of a dragon, and was offered any reward he chose by the grateful king. He thought a moment, and replied, "Your majesty, I have always been fascinated by the game of chess, which, as you know, is played on a board with 64 squares. My request is that you reward me with one grain of wheat for the first square on the chess board, two for the second, four for the third—an so on, always doubling, until you have paid me for all 64 squares." The king quickly agreed, thinking this a foolishly simple request when the knight could, instead, have asked for half his gold or his kingdom. He soon learned, and you can easily compute, that he didn't get away so cheaply—he had contracted to pay with more wheat than ever could or would be produced on earth, showing again that with powers of two, we can quickly reach astronomically high figures.

BINARY ADDITION TABLES

$$0 + 0 = 0$$
$$0 + 1 = 1$$
$$1 + 1 = 10$$

A BINARY ADDITION PROBLEM

		11	.... Carry
3	=	0011	
6	=	0110	
9	=	1001	

FIGURE 3

Why do our computers use binary instead of decimal numbers? One reason is that it is difficult to build electrical circuits which can recognize ten different digits, which show up in the computer as ten voltages. On the other hand, it's quite easy to design a circuit that can recognize two conditions. For example, to tell the difference between a voltage present, and a voltage absent, or between a light on or off. A second reason for using the binary language is this: Our computers have to do arithmetic, and it happens that binary arithmetic is simpler than decimal arithmetic. Not for us, perhaps, because we've all learned the decimal system. But were we starting from scratch, knowing no arithmetic at all, we'd find binary arithmetic much easier to learn.

There are only a few rules we need to remember. Let's talk about addition. In our decimal system, we've had to learn in elementary school that 1 and 2 make 3, 2 and 2 are 4, 5 and 4 are 9 and so on for a great many combinations, all of which we've had to memorize. In the binary system, there are only 3 rules for addition (Figure 3). With these 3 rules which we must memorize—or in the case of computers, must build into the circuits—we can perform any addition, no matter how complicated. We can try this by adding 6 and 3. The binary equivalent of 6 as we can find from the translator, is 0110, and the binary equivalent of 3 is 0011. If we add these using the three basic rules and remembering that we have to carry just as we do in conventional addition, we'll get the answer 1001, which we can easily check and find to be the binary equivalent of 9. (See Figure 3.)

That's addition—what about the other branches of mathematics? Subtraction is merely the addition of complementary numbers. Multiplication is simply repeated addition, and division is repeated subtraction. So that takes care of arithmetic. Integrals, differential equations and other mathematical expressions can be approximated

in numerical form—not exactly, but we can get as close as we wish by using smaller intervals between quantizing steps. So, with the help of a computer programmer, virtually any mathematical problem can be expressed in terms of addition of a lot of binary 1's and 0's; admittedly, a great many in some cases, but given an experienced programmer, the job can be done.

Computer engineers often refer to these binary one's and zero's as yes's and no's, and in that connection they cite Biblical authority for using binary numbers. Specifically, from the Sermon on the Mount, "Let your communications be yes, yea; nay, nay: for whatsoever is more than these cometh of evil."

The rules of binary arithmetic are simple and few in number, and this is one big reason for using binary language in computers: We have only to "teach" the computer a few simple rules. Now that I've mentioned "teaching" the computer things, we can get to the second part of our discussion—how does the computer learn and think, so that it can solve the complicated problems we give it in such a short time?

What is thinking? Let's say for the moment that it consists of remembering things—memory—plus the ability to use what we've remembered to solve new problems as they arrive—logic. Two things, then—memory, and logic—and our computer has lots of both. Let's talk about these two features one at a time—first, memory.

The human brain consists of about ten billion cells, which "store", or remember information in much the same way as computers that is, in binary form. Computers have brain cells too, but even the largest of them don't have nearly as many as the human brain. At the top of Figure 1 we have some computer brain cells: these are the four circular magnetic cores mounted on a small plastic card. These are magnetic memory elements, and they can store or remember information in binary form. A typical large computer will have over a million of these. Plugging this memory into the translator as it is shown in Figure 1 we can store in it in binary form whatever number we have set up on the translator. We can then unplug the memory core, and it will remember this number as long as we like. This memory isn't forgetful the way our own sometimes are. At some future time, possibly later in a series of computations, the computer wants to refer to this memory to see what's stored in it. We can read this memory by plugging into a reading unit (Figure 4) and the proper lamps will light on the reader corresponding to the binary number that we originally had set up on the translator and stored in this small magnetic memory. Magnetic cores are not the only types of memory that we have. In addition to magnetic cores such as these we have magnetic tapes, photographic film plate memories, electrical capacitors, and quite a few other types—but they all perform the same function and they all do their remembering in binary form.

The world's best memory is useless unless we apply it to some useful purpose, and the process of applying what we remember to problems in everyday life is called *logic*. Every computer ever built has a vast network of logic circuits within it. Logic circuits, then, have the ability to solve problems.

FIGURE 4

Figure 5 shows an electronic circuit which can solve problems—a logic circuit. The circuit is built on the four plastic cards protruding from the board and consists of resistors, diodes, and transistors. Each of the cards is what we call a logic "gate". You could think of these like gates in a fence. Imagine a gate with two locks. If it is arranged so that we need to operate both locks to open the gate, we call it an *and* gate—we need one key *and* the other. On the other hand, it might be arranged so either lock will open it—we'd then call it an *or* gate; it can be opened with one key *or* the other. These electronic gates work the same way. The gates at the lower left and at the center are *and* gates: if we apply voltage to both of the two input wires at the left, the voltages are like keys, the gate opens and the voltage appears at the output wire on the right. The gate in the upper left corner is an *or* gate and gives us an output voltage. On the far right is an inhibit gate: while voltage is present on the lower wire, the gate is held closed and there is no output voltage.

I said this circuit would solve problems, so let's take

FIGURE 5

an example: a type of problem most people have to solve some day, but most likely without the help of an electronic brain. Let's put ourselves in the position of a young man who is giving some thought to getting married, and let's assume that he has some rather definite ideas as to what he wants in a wife. Let's assume that this particular young man wants to marry a beautiful girl; but if she's rich she doesn't need to be quite so good looking. Then, he also enjoys dancing—so he wants a girl who can dance; and since he likes to eat, he'd like to marry a good cook. We all know the problem is a bit more complicated than this, but let's assume we can find out whether a particular girl is the right wife for this young man by asking these five questions:

1. Is she beautiful?
2. Is she rich?
3. Can she dance?
4. Can she cook?
5. Is she already married?

Notice on our electronic logic circuit (Figure 5) that at the left end we have five switches. Each of these five switches corresponds to one of these five questions. A switch in the vertical position as shown represents a *no* answer to our question and if we turn the switch to the horizontal position, it represents a *yes* answer. Now we could use our computer to determine whether this hypothetical girl is the one our young man should marry. Let's assume that she is not beautiful, so we'll put the first switch in the vertical or *no* position. Assume she is rich, can't cook, can dance and is not already married and set the remaining switches accordingly. The lamp on the right is the output of the logic circuit: lighted it represents a *Yes* answer to our problem. Notice that in this case it's not lighted so the answer for the conditions we've assumed is that this is *not* the right girl. The reason, of course, is that we didn't supply both inputs to the lower lefthand *and* gate, so it remained closed. If we correct this condition by assuming that she can cook, we'll then satisfy the requirements of the logic circuit, the light comes, and the answer becomes *yes*.

This is a very simple example of a logic circuit; in a computer, we would have thousands of such logic circuits, interconnected in a way to solve the particular types of problems we need to solve. However, we have shown here that it's possible to build electrical circuits which can analyze situations, weigh them one against the other, and, using logic, arrive at the correct answer.

One point may have disturbed you. This was a simple problem; the problems of figuring the flight of a missile or computing a payroll are much more complex. However, all these problems can be translated into binary numerical form and handled as a series of a great many yes and no decisions. The important thing which makes these electronic computers possible is that these many decisions are made in microseconds. A microsecond is literally a millionth of a second, and it's rather hard for most people to conceive a period of time as short as a microsecond. Perhaps a couple of comparisons will help to show how quick an operation that requires a microsecond really is. As one example, there are about as many microseconds in a minute as there are minutes in the average man's lifetime; or as another example, it takes a jet plane traveling at top speed considerable more than a microsecond to travel the distance represented by the width of a toothpick. So you see, the thing that makes our high-speed electronic computing systems possible is the fact that we can use electronic circuits with no moving parts which operate in time measured in microseconds. What are the building blocks of these super high-speed circuits? Vacuum tubes, transistors, semiconductor diodes, magnetic tape and cores—and a host of even newer devices just beginning to come out of our research laboratories which will make even microsecond operations seem slow.

There is far more to a modern electronic brain than we've covered here, but these three things are fundamental to the workings of all of them large and small. They do their calculating in binary language, they can remember a tremendous amount of information and recall this information from their memories in millionths of a second, and they can apply logic to a set of conditions and arrive at a solution faster than you can blink your eye. Binary numbers, memory, and logic—fundamental to all electronic brains.

They're revolutionizing business operations. They are helping us to solve mathematical problems we couldn't handle before. They're allowing scientists to analyze vast masses of data, increasing our knowledge of the universe. To return to the more prosaic, some of you may wonder why a telephone engineer should be interested in computers. We like to brag, like anyone, and it happens that we have the world's largest computer, which all of you have used. The input to this computer is your telephone dial. The coding for this computer consists of the pulses or tones representing the numbers you dial. The computer in your local office decides how your calls should be connected. If the problem presented to it is beyond its limited ability to solve, it calls in a more "intelligent" computer—and we have a whole hierarchy of computers of this sort, each performing functions of a different nature suited to the particular requirements. The call you dial may be established through any of many alternate routes to reach the particular correct one of the fifty million telephones in the United States, and may use the services of from one to ten of these giant "brains". These machines, or computers, that connect your calls have to receive information, analyze it, remember things, look other things up, and make logical decisions; then finally, they direct the setting up of the proper one out of many million possible connections, and then make the proper records for billing purpose—truly a remarkable computing operation.

I hope that I have given you some idea of how these marvelous "brains" work. They're going to have quite an effect on our lives in the next few years. Some people don't have much faith in them—at one computer installation, I'm told that beside the control panel is a glass case, and inside the case, an ordinary slide rule, with a sign saying, "In case of emergency break glass."

On the other hand, some people have too much faith in computers and think some day these brains will push us aside, think for themselves, and make us their slaves. I don't really think we have much to fear in this line but let's just imagine for a moment what might happen.

Physics for the Less Gifted Student

• **By Sister Ignatia Marie, O.P. M.A. (Ohio State University)**
ST. THOMAS HIGH SCHOOL, BRADDOCK, PENNSYLVANIA

Teachers too frequently discourage slow learners by leaving them out of everything that seems too difficult. The author of this paper experimented with a challenge to weaker students.

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Somewhere I have read the statement, "It is faith in theories, faith in data accepted by other people without any assurance that such data are valid, that keeps scientists going." As a high school science teacher I want to paraphrase it thus: "It is faith in students, even those of low I. Q. that keeps teachers at their desks, that urges them on to ever greater strivings." And that is why I attempted this experiment. I have always felt that if only one student has been helped to fill a vocation for which he has the ability but, due to lack of previous interest or training, has never aspired before he entered my classes, then I will have been well paid for my efforts.

This study was made with a group of eleventh grade students whose I. Q.'s ranged from 77 to 96. A standard textbook and laboratory manual were used in the course and the same number and type of experiments were required from these slow learners as I required from my better group although greater percentages of error were permitted. Thirty experiments, worked individually was the goal set, and psychologically I felt that it would be better to let these students know the requirements of the course from the outset.

At the first class meeting, I explained all the regulations pertaining to the course. I told them that assignments made one week in advance would be posted on a bulletin board in the classroom; hence all insecurity concerning homework would be abolished. All students were cautioned about wasting time in the laboratory, since thirty experiments were required for a completed course. Each student must hand in a written report of the experiment which would be corrected that same evening. If the experiment had been satisfactorily worked, the report sheet is not returned, but if the experiment must be repeated, or if data has not been properly recorded, the papers will be returned with directions about correct procedure.

All assignments must be handed in before the start of each class period. Three days a week; on Mondays, Wednesdays and Fridays, a lesson from the textbook is expected and, for a double period, on Tuesdays and Thursdays, the group reports to the laboratory supplied with manuals and pencils. Data may not be recorded in ink and scrap-paper notes are frowned upon.

I took only fifteen minutes of the period for these preliminaries and plunged at once into the planned lesson—the metric system. I introduced the centimeter, after having compared the meter and the yard, using a meter stick and a yardstick for the demonstration. I explained how and why the metric system came into existence. The group seemed stimulated; later in the day two other students in the low I. Q. bracket came in and asked if they might take physics. When I questioned them, they told me that their friends were talking about the class at recess period. Here I had what I was looking for—students who wanted to learn but felt that physics was too hard for them.

At the second meeting, the group was taken to the laboratory. The students chose their own lab. partners, making about fifteen separate groups. I did not assign special work tables but instructed the students that each group worked independently. I tried to create a spirit of ease and freedom. I assigned experiment #1 to five pairs; experiment #2, to the next five, and experiment #3 to the last five. The remaining four took experiment #1. These four seemed almost hopeless and I felt that they were going to need almost individual attention all the time. The first group were given some simple instructions: draw a triangle, the sides of which were to be measured in both systems, all data to be recorded and from these figures, the number of centimeters in one inch was to be computed. Group 2 measured the cross-section and circumference of a circular cylinder in centimeters and found, from their data, the value of pi. Three learned how to use the vernier caliper. I explained that I am only one individual but would give each group as much attention as they needed and I expected them to use their hands as well as their heads. I took two students at a time for instruction on the caliper; two readings with them, checking one reading for each student, and left them to check each other. It amazed me to find that these students lacked the knowledge of the use of a ruler and also the process of tabulating data.

These three experiments were worked on for the next three or four weeks, many of the students came into the lab. at lunch time and after school to learn how to read the calipers and how to use the balance, some asking if they might come in on Saturdays and Sundays. No one was turned away while some of them had to change their schedules because they felt that they could learn physics, i. e., that it was not too hard for them.

The lecture periods were made very stimulating. The first item taken care of was any difficulties which might have been provoked the previous day or any questions which they did not fully understand on the home assignment. The first few days I was asked no questions, so I created some very simple situations which they were asked to explain, such as: "Which would you prefer to have, a quart of milk or a liter of milk? Some of our soldiers who are in France tell us that they get more silk in the yard there than they do here. Is this true?"

Each lesson was explained in great detail and each new idea was clarified by demonstration. All explanations dealt with everyday experiences, for example I explained inertia

—but it was only after I told them of the experiences of mothers with getting children into bed at night (objects moving) and getting them up in the morning (objects at rest) that it sank in. I went on with experiences such as they would have, such as placing a diary in a secure place and finding that diary months later in exactly the same spot (unless moved by some external force). We went on to auto accidents, accidents at home and on the street, and from there to the need for inertia in such devices as the flywheel in the automobile and steam engine. When we studied the special properties of matter, I explained the origin of the word, such as ductility, from the Latin word, *ducto*.

They laughed at my funny sayings. I usually use 'stick' men for very simple drawings which I simplified even more with these slow learners, many of whom I was trying to show some significance in familiar material.

At the completion of each unit, such as measurement and density, a test was administered. After the papers were corrected, they were returned to their owners. We then went over each question and all problems were worked. They were permitted to change a mark if they had been deducted because I could not decipher their writing. I found that these students were very poor readers as well as spellers. I tried to show them the advantage of printing the answers. If they did not know what the word meant, they were badly handicapped although they might know the physical law governing the situation. One example that comes to mind is a question on the conservation of "matter" which used the word "annihilation." These children were not familiar with the word, not even the keenest among the group. I explained the meaning of the word and gave them a half-minute to change the answer which they had previously written. If they had answered it correctly this time, they received credit.

Many of these students had had trouble with arithmetic in the grades. I encouraged them to come in after school and we had many a session of long-division and square root, decimals and fractions. I promised to teach them some tricks with numbers and we learned that, if the sum of the digits of a number is divisible by three the number is divisible by three, and the like. I took advantage of this mishap with the arithmetic processes to teach the use of the slide rule. I devoted ten minutes every lab. period to the use of the slide rule. By the end of the year about sixty-five per cent of these students could multiply and divide by two numbers as well as find square roots and cube roots, on the slide rule.

Each lesson was taught three times. First, a new idea was introduced and explained fully; the students were given a home assignment on that topic for the following lecture period (two days hence because of the lab. period) and on the day that the lesson was due, the entire period was devoted to the topic. Three or four days later we reviewed the lesson by either answering questions at the end of the chapter or by a short quiz. The chapters on force and pressure had to be reviewed at least five times and each time we worked the formulas. Each time that a problem was worked, I asked what we were looking for and what had been given. A table of these values was then made and afterwards fed into the formula. I taught them the importance of the units, which we cancelled out just as we would the integers. These students became very familiar with the formula for density, yet it took a great deal of drill before they knew how to find volume if density and weight were given. Their questions invariably were: "But what do I put inside the box?"

The units on atmosphere and atmospheric pressure were made very practical. I assigned for a homework lesson, the weather report given on station KDKA-TV in which the forecaster draws in, on a map, with simple lines, the weather conditions throughout the entire United States. The class was required to hand in two days later, a map of the United States showing high pressure and low pressure areas. We predicted the weather and discussed the reasons for "shower activity" and "icing conditions."

A difficult idea to put across was resolution and composition of forces. Even after working a few experiments, the ideas seemed hazy but here again we reviewed and repeated assignments. Acceleration and velocity were ideas which needed a great amount of clarification. We talked about an accident which a painter had sustained when he fell from a scaffold, calculating his velocity at the end of the fall. We took hypothetical accidents and calculated acceleration; we secured information about aviators who had to bail out. The test which I gave on motion, velocity and acceleration was really a sorry sight. I gave thirty questions and deducted three points for each mistake. The marks ranged from 33 to 70.

The unit on heat presented some problems for this group. We spent several days testing the freezing and boiling points of water. Change of state was obscure to these students although we tested the freezing point of water and the melting point of ice. I am not certain that they ever got the idea of heat of condensation. Change of state was a hurdle—I am not certain that we ever really got over it. Here we used the formula $MTS = M'T'S'$ in which we agreed to let the primed letters symbolize water. It was necessary to stress the fact that T was not temperature (degree of heat) but change of temperature (quantity of heat).

To bring out the idea of heat and energy I used General Motors series of four films on internal combustion and the automobile, diesel engine and the jet.

In this unit, I had to again review the metric system, stressing liters and milliliters, grams and milligrams. I drilled, drilled and drilled about the differences between the Centigrade and Fahrenheit scales and gave them a standard formula $\frac{F-32}{9} = \frac{C}{5}$ which they could use for either scale. Everyone in the group worked at least twenty-five problems using this formula.

The units on mechanics and heat were the only ones taught in the first semester. The advent of mid-year examinations gave me an opportunity to review the work so far covered. I administered a standardized test composed of seventy-five items which consisted of problems, completion questions, true-false statements and matching. The results were as follows:

No. of items	No. correct answers
61 - 70	1
51 - 60	1
41 - 50	4
31 - 40	10
21 - 30	15
11 - 20	2
1 - 10	1
Total	34
Class median	28.7

I was not discouraged with the test results although the passing mark for our school is 70%.

In the second semester, the same pattern of procedure was followed. I spent only two weeks on sound, stressing just the highlights because I realized that I could not cover all the subject matter in the text.

"Light" was a real challenge but most of these students mastered the salient points. Some repeated the experiments on plane and curved mirrors thirteen or fourteen times, the excuse for poor results always given as poor eyesight. I joked about saving all the poor trials—one little girl had nineteen.

By comparison, magnetism was easy. I was amazed when I started to teach the unit on electricity. They seemed to grasp the principles very quickly but tests showed that they did not understand too well. We electro-plated tie-clasps and spoons with copper solutions; some of the boys tried some nickel plating and results were not too poor. We checked the voltage of batteries, securing a wet cell from a junk yard and a B battery from a radio shop. Strings of Christmas-tree lights helped to make clear the idea of series and parallel circuits. We took a motor apart and tested the magnets; we strengthened the field by using more powerful magnets and they grasped the idea of the electromagnet. We changed the wires making series and shunt motors. They seemed to like the work they could perform with their hands but it was necessary to drill and drill when it came to the reasons for the procedure.

We did not delve into electronics too deeply. We secured some discarded radio tubes and examined the elements. We studied the radio tube, making charts showing the essential parts of the diode and the triode. One of the boys made a crystal radio set which gave us the basic principles of radio transmission. I explained radar just as I would echoes in sound and we went on a tour of the x-ray room of a local hospital. I was not too satisfied with the results of the test on this unit.

For the final examination I used a different technique. I explained that we all had our good and bad days. If the class wished, we would take three examinations in physics and the highest grade received by any student in an individual test would be considered the examination mark. I spaced the tests about two weeks apart, giving the first one in the second week of May. This gave me an excellent way to drill. After each test was corrected, the papers were returned to their owners and we went over each question. We checked the items which were hazy and spent extra time on them. After this drill we took a second test, not too unlike the first and the same procedure was followed after the tests were corrected. The third test was given on the day scheduled for the final examination.

Results

Every child in the group except one received credit for physics. The one student who did not receive credit for this course had not turned in her assignments, had performed only eighteen experiments and did not seem to care. Two boys in the group decided to become technicians, and realizing that they were poor in mathematics, enrolled in summer school. Some of the others felt that they belonged in the business world although two girls wanted nursing.

Conclusions

Working with this group was a revelation to me. Most of these students were poor readers and I had to use very simple language in all lectures. It was very difficult to hold their attention for more than a half hour at a time. I had to change my tactics often or they would become listless. Infinite patience was needed at all times so that a feeling of inferiority would not be developed. I praised the slightest effort made and tried to show these students how stupid it was to copy. They were permitted to examine my daily-mark book at all times and to average their marks and hand in their on report-card mark. Teachers who had these students in study-hall told me that physics was the most popular study; the children seemed to enjoy it and always wanted to get it finished first.

I am anxious to make a follow-up study on these students. Have they been given enough encouragement to face the harder things in life?

PHYSICS FOR THE LESS GIFTED STUDENT

Textbook used:
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Laboratory Manual used:
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Supplementary text:
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Text used by Teacher, when lesson was prepared:
White, Harvey E., Ph.D. Modern College Physics. New York: D. Van Nostrand Company, Inc., 1953.

Films used:
General Motors:
ABC of the Automobile Engine
ABC of the Diesel Engine
ABC of Jet Propulsion
ABC of Internal Combustion

Standard Test used:
Dunning Physics Test (Form AM)

★ ★ ★

Flower Arranging for Teens

• **Sister Claretta Easter, O.P. M.A. (University of Wisconsin)**
CATHEDRAL HIGH SCHOOL, MILWAUKEE, WISCONSIN

Do we overlook the aesthetic values of our classrooms and laboratories?

Here is a project that can add interest to the study of plants, and enable the student to develop a sense of beauty and proportion.

●

A bunch of golden dandelions clutched in the hot little fist of the smallest child is evidence of the love of flowers instinctive in all of us. This love should be fostered in home and school. More often than not, it is neglected in both places, expense and inaccessibility being the reasons most frequently given. What better place than a sophomore biology or botany class to satisfy that love, since the students study of botany has given them a keener appreciation of all plant life.

Since the purpose of this article is to provide "material widely applicable and of immediate usefulness to the teacher instructing in science," we shall try to do, just that. Much of this has been said before with elaborate details and illustrations. My idea is to condense these numerous suggestions into proportions suitable for use as a unit in a sophomore biology class.

Depending upon the amount of time allotted, general information about the art of arranging flowers, would be given by either the teacher or a group of students. Briefly this general information would include some ideas of the Oriental and the Occidental methods; the principles and rules developed by each. Next some understanding of basic designs, balance, scale, focus, color, rhythm, accent, harmony, choice of container and materials should be considered. All will agree, however, that detailed knowledge of the above is not essential, since the main motive for flower arranging is self-expression that is free and unhampered by fixed rules. The following then is the matter we have evolved from our readings and experience.

Basic Designs

1. *Side triangle,* generally the most popular, but you will notice from the illustrations that it was attempted by only one student; (Fig. 7) her version being the base line longer than the side line.
2. *Circle,* curving lines that almost meet, with a low accent, attempted in (Figs. 8–9).
3. *Triangle,* this can vary in as many ways as there are types of triangles. (Figs. 5–6).
4. *Crescent,* in which the main line is of equal height on both sides or tipped. "Material available, they felt, was not suitable to this design."
5. *Hogarth Curve,* a rhythmic and graceful S curve.
6. *Perpendicular,* slender container, high arrangement with a mass of flowers about halfway up. (Fig. 4).
7. *Oval* and *half circle* were ignored. Fig. 10 might have been a half circle, but "got side tracked" by using too much material.

Scale, materials should be selected that are related to one another, the container, and the location.

Design, is the plan of an arrangement. It must show relationship to container, location, flowers and foliage.

Balance, two kinds (1) symmetric, both sides the same (2) asymmetric—two sides definitely different but appearing equal in weight, and pleasing from any point. Arrangement should not be top-heavy, but stable. Heavier flowers and darker colors below, working to lighter buds or foliage and paler colors above.

Color, let yourself go! Vivid, pale, monochromatic, analogous, mixed, cool or warm all are suitable but keep the dark colors where they won't "fall out" of the arrangement.

Rhythm, acquired by following a definite design which need not be a basic one.

Focus, the eye-catching point—other parts are placed to lead the eye to that point.

Accent, the unusual use of material, color or texture.

Harmony, achieved when the created whole expresses your idea.

Choice of Container, anything that will hold water is a suitable container. However, plants and container should complement each other. Suitability not value is most important. Heirlooms that you love and treasure, kitchen utensils or the dime store item that suits the immediate mood are equally acceptable. A soup ladle, containing a sweet potato vine, is most attractive hung on a kitchen wall.

A group of containers (Fig. 2) picked at random and easily available might include, a teapot, delicate green in color, a cracked Willow Plate, a "chunk" missing from the rim, florence flask and graduate cylinder, "lab dishes," frying pans, cups, casseroles, and copper boilers discarded by the chemistry lab. Such items as Steuben and Onofores glassware, or antique silver compotes, we leave for the Garden Club Women. One warning, do not permit the container to detract from the flowers.

Tools, small sharp knife or single edge razor blades, needle-point holders in various sizes, heavy lead ones, not plastic, glass holders, fine wire, chicken wire, shears to cut wire and shears to cut foliage, waterproof clay, parafilm to tie stems.

Plant Material—the amount and variety is limitless no matter at what season you present this unit of work. *Dried material*—collect in June and July large clusters of the fruits from ailanthus, maples, ash, box elders linden, sumac. Collecting these at various times during the ripening process will give a variety of colors. In early and late summer pick Queen Anne's lace, cox-

Fig. I. Face and head is a tin can and doll's straw hat.

Fig. 2. Anything that will hold water is a suitable container.

Fig. 3. Selecting materials.

Fig. 4. Perpendicular.

Fig. 5. Triangle—"overdone."

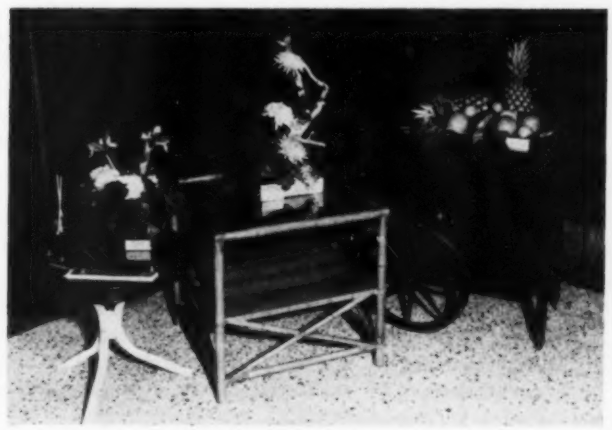

Fig. 13. Biol Floral Arrangements.

Fig. 6. Triangle.

Fig. 7. Side triangle.

Fig. 8. Circle-curving lines.

FIG. 9. Circle-Longspike spoils effect.

comb, salvia, statice thistles, and yarrow. Hang these to dry heads down in darkness to preserve their color. As fall approaches take your choice of yellow, red, purple, brown leaves, dried grasses, grains, weeds; dry fruits such as acorns, iris, gladioii, catalpa, locust, coffee tree and okra seed pods; gourds, Chinese lanterns, artichokes, both flower and fruit. The woods will yield pine cones, fungi, dead branches, bark, fern sporophytes, milkweed pods. These combined with pine, spruce, fir and cedar are delightful. Vacant lots or roadsides will furnish golden rod and seed heads of sunflowers. Straw flowers provide vivid color and pleasing form.

Spring flowers, most students are familiar with many of these, except perhaps those of shrubs, and trees. It is always a delightful surprise to them and a soul satisfying experience to see forced blossoms on apparently dead branches of forsythia, maple, elm, oak, apple, cherry, peach, plum, pear, quince, and pussy willow.

Finally don't forget the charm of the commonplace namely—

FLESHY FRUITS, many of these are vegetables to those who don't know botany. These lend themselves equally well to formal elegance or intriguing informality. Peppers, red and green; tomatoes, red, green, yellow, small or large; squashes, cucumbers, melons, crab apples, pomegranates, avocados, egg plant, persimmons and citrus fruits. Foreign to this category, since they are specialized stems, the lowly potato (also in several colors and sizes, Idaho, red and sweet) adds a note of the unusual to a plant arrangement.

After discussion, demonstration and study of the preceding, experimentation is the next step. Pairs, or larger groups choose containers (Fig. 2), materials (Fig. 3) and location. Movable table-type desks make it possible to change them to any location. Their size, too, is ideal for a single floral

(*Continued on Page 134*)

FIG. 10. Half circle until too much was added.

FIG. 11. Cool greens, dove grey plate, bittersweet wall.

FIG. 12.

Emphasizing the Process as Well as the Product of Science

• By John H. Woodburn, Ph.D.
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Students who think for themselves are the product of good teaching.

Is your teaching producing students capable of independent thought?

The following is from a paper presented to the Pennsylvania Catholic Round Table of Science, Spring Meeting Saturday, April 11, 1959, Immaculata College, Immaculata, Pennsylvania.

●

The science teaching profession nowadays is enjoying an extremely poor press. Scarcely the day goes by that some expert fails to make the headlines with his viewing with alarm the horrible state to which he thinks the teaching of science has degenerated. This I deeply resent and regret because if it is true that nothing succeeds like success, then we might argue that nothing is any more likely to fail than failure. It is not that I want to deny our critics their right to make the headlines, but these critics seem to be producing an environment in which teachers who are sensitive to criticism as a means of revealing hypotheses whereby improvement can be sought are less likely to survive than are the thick-skinned members of the profession who are insensitive to criticism. What I am trying to say is this—if I cite criticisms of the way science is taught, it will be solely to point the way for possible improvement.

And now, I would like to get your thinking underway by citing a British scholar, Westaway, who said in 1912:[1]

> It is a great misfortune that 'most of the present science teaching in English universities seems to be directed to cultivating the deductive faculty.' In essence, the training is mathematical. The man who is working for a science degree usually takes on trust nearly all he is told in the lecture theatre. He is not put in the position of an investigator at all. He receives his information on authority; his practical work is mainly intended to verify principles he has already accepted; and his training is thus very little calculated to imbue him with the scientific spirit. One university is notorious for the high standard it exacts in its paper examinations for a science degree, yet the practical examinations are so trivial a character that candidates can prepare for them by spending less than six months in laboratory. The consequence is that many young science teachers form, at the very outset, an entirely wrong conception of what scientific method really is. How can such a teacher be expected to engage in successful heuristic teaching when he himself has never in his life undertaken the simplest piece of research work? (Incidentally, I had to look up the meaning of that word "heuristic" so let me share what the dictionary had to say about it: "A teaching method encouraging the student to discover for himself.") His outlook is altogether wrong. He sets to work in school exactly as he was taught to set to work at college. How, indeed, can he be expected to do otherwise? He is entirely unaware of the specific functions that science teaching is intended to perform. He teaches Science just as he would teach History. He considers it his sole duty merely to pass on information. The spirit of his work is, 'Believe, and ask no questions.'
>
> If the young teacher desires to master scientific method, he must follow the history of Science, and see how one faulty method has been superseded by another, which, in its turn, has itself been superseded, so difficult has it been to discover the principles of the true method; he must learn to get at the exact bias from his facts; he must ever be on his guard against hasty generalizations; he must ever be ready to give up a pet hypothesis, once the facts are against him, and he must never, on any account, allow his hypotheses to masquerade as facts—'hypotheses are cradle-songs which lull the unwary to sleep'; he must acquire a knowledge of the laws of inductive reasoning; he must learn to balance probabilities; he must remember that even the best conclusions of Science are never more than in a high degree probable; and he must study the original records of successful investigators.

Now it is this last paragraph that is the heart and soul of everything that I will try to bring you. And, frankly, I find it a bit ironical to admit that Westaway, writing some forty-seven years ago, seemed to have greater insight than I have now of how to emphasize the process as well as the product of science.

Now, I would like to present one more citation because I think it brings most clearly into focus one of the biggest road blocks toward the improvement of our teaching. In this case, I am turning to Karl Pearson who, under the title of *The Grammar of Science*,[2] had this to say in 1892:

> Science, indeed, often teaches us facts of primary importance for practical life; yet not on this account, but because it leads us to classifications and systems independent of the individual thinker, to sequences and laws admitting of no play-room for individual fancy, must we rate the training of science and its social value higher than those of philology and philosophy. Herein lies the first, but of course not the sole, ground for the popularization of science. That form of popular science which merely communicates *useful knowledge,* is from this standpoint bad science, or no science at all. Let me recommend the reader to apply this test to every work professing to give a popular account of any branch of science. If any such work gives a description of phenomena that appeals to his imagination rather to his reason, then it is bad science. The first aim of any genuine work of science, however popular, ought to be the presentation of such a classification of facts that the reader's mind is irresistibly led to acknowledge a logical sequence—a law which appeals to the reason before it captivates the imagination. Let us be quite sure that whenever we come across a conclusion in a scientific work which does not flow from the classification of facts, or which is not directly stated by the author to be an assumption, then we are dealing with bad science.

Now, if the writings of these two scholars, Westaway and Pearson, are valid today, they bring sharply before us two avenues through which the improvement of our teaching of

science might be sought. From Westaway's citation, I would underscore—*"He sets to work in school exactly as he was taught to set to work at college."* This suggests to me that if we are dissatisfied with our teaching of science, especially the process of science, we are going to have to go back and re-examine our own whole participation in the learning of the science which we propose to teach.

From Pearson's writings, underscore this sentence: *"Let us be quite sure that whenever we come across a conclusion in a scientific work which does not flow from the classification of facts, or which is not directly stated by the author to be an assumption, then we are dealing with bad science."* And now, again, if Pearson's citation is valid today, it becomes a sharp condemnation of many, many of the textbooks from which we would hope to have our boys and girls learn good science.

I fear that my remarks have been more critical than constructive. But I believe this is a matter of emphasis. The constructive phases of my remarks appeared in an earlier citation, and even at the risk of adopting some methods ordinarily reserved for our much-publicized slow learners, I would like to have you re-read the second paragraph of Westaway's citation.

And now, how can we do what Westaway recommends? Throughout the literature which our profession has accumulated in the past years, three or four rather promising practices have captured my interest and at least a bit of my enthusiasm. These are the case history approach, the case analysis approach, taking lessons from logicians, taking lessons from industrial and university research, and the junior excursion into science, more popularly known as the science-project.

The first two of these promise to improve science textbooks and I hope you recall what Pearson has had to say about them. I assume you are familiar with them, but I will review, quite briefly, my interpretation of these two approaches to the preparation of textual materials. In the case history approach, an episode in science is selected which holds promise of bringing clearly into focus the tactics and strategy of science. The state of man's knowledge of the general topic prior to this specific episode is reviewed. This is followed by a portrayal of the events and circumstances leading up to the new hypothesis forming the heart of the episode. The tactics and strategy which were reflected in the testing or investigating of the new hypothesis are spelled out in great detail. This is followed by an interpretation of the immediate and ultimate impact of the episode not only on science but on man's other affairs. And the case history closes by bringing the student up-to-date with a brief review of our present-day knowledge of the topic with which the episode deals.

The case analysis begins similarly. An episode in science is selected. Then, by careful analysis of the episode, the student is led to see how scientists (a) recognize and state problems, (b) evaluate, select, state, and test hypotheses, (c) select, ferret out, evaluate, and apply information in relation to the problem, (d) recognize assumptions, inferences, and generalizations, (e) form conclusions, and state them within the limits of probability imposed by their experiments or investigations, and finally, (f) translate their critical consideration of their conclusions into attitudes, opinions, actions, or beliefs.

Taking lessons from logicians or at least the students of logic is, in my mind, the most neglected and yet the most promising avenue toward which we might seek improvement of our teaching of science. Only recently have scholars overcome the tendency to make an intellectual parlor game out of the study of the thought process and begun to look at the act of thinking as it is logically applied to exploration, discovery, and invention. If any of you here are looking for ways to advance the teaching of science, here is where I would wave my brightest flag.

Within recent years there is an increasing tendency to bring teachers into closer contact with practicing research scientists. Where teachers have an opportunity to force a scientist to reveal the origin of his hypothesis, admit to all of the blind alleys he explored before he came to his fruitful hypothesis, to recite in detail his stumbling tactics leading to the design of his experiment or investigation, and to give a clear estimate of the probability of the accuracy of his findings and how they have influenced his activities since concluding his work, these teachers tend to have a good exposure to the process of science. I must add, however, that teachers do not get this sort of thing by simply walking up and down the halls of a magnificent research laboratory.

Many of the people with whom I associate would be real proud of me to see that I have talked this long without getting to my commercials for science-projects—the final suggestion that I have for those who would seek ways to emphasize the process as well as the product of science. And for you, no commercial is necessary. Assuming that you have had the satisfaction of bringing the youngster's interest in some thought-provoking, curiosity stimulating facet of his environment into sufficient focus that the youngster has been able to set up a reasonable hypothesis, design an experiment or investigation to test the hypothesis, and to know the satisfaction that can come only from his own discovery of what was to him a satisfying solution to his problem or explanation of the things which had aroused his curiosity. Those of us who have enjoyed this contact with science-projects need no commercial. But I hope you see that I am referring to a specific kind of science-project, and I find very few nice things to say about the pastepot and scissors type of investment of the student's time and the resultant neutralization of possible enthusiasm for science which is so likely to happen when students are allowed to do a science project which is by no means a genuine excursion into the enterprise of science.

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★ ★ ★

During 1959 The National Foundation, supported by the New March of Dimes against birth defects, arthritis and polio, spent $16,500,000 in patient aid to more than 50,000 polio patients, many of them stricken in previous years.

Casey Colloid and His Characteristics

• **Sister Mary Michael Ann, P.B.V.M.**
PRESENTATION JUNIOR COLLEGE, ABERDEEN, SOUTH DAKOTA

The following is the story of a colloid as he goes circulating through your blood stream every day without your even being aware of his existence. This is all first hand information as the little colloid himself tells his own story in a short autobiography.

●

Hello Folks! My name's Casey Colloid and I'm really a pretty unique individual. I'm not bragging and I don't want you to think I'm proud, but believe me there's just no other substance on the face of the earth that can act just like I act. I thought about showing you my picture, but I guess that's just a bit impossible. I never look the same way twice. There's just no end to the poses and positions you might find me in.

I suppose some people think I'm a bit two-faced. You may find me in solution one moment and quicker than you can blink an eye I'll be changed into a gel. Of course, there's no cause for alarm. The change hasn't harmed me any and be assured that before long I'll be changed right back again.

I'd like to take you around to see the rest of my family before I tell you any more about myself. There's my delicate, refined sister, "Tessie-True-Solution," and then my brother, "Samuel Suspension." I'm quite fond of both of them. We're not exactly alike, of course, but there is a family resemblance. In some of our poses we do look alarmingly the same, but just stay with us for a while and do some close observing and you'll find out that we each have a few distinct characteristics of our own.

Since this story is my autobiography, I'm not telling you all there is to know about my brother and sister. I'll let you know the most important points for distinguishing us from each other, however.

First I'd better explain to you, that wherever you find Tess, Sam, or myself you'll find us in dispersion. There's any number of things we might be mixed with, but chances are it will be just plain water. All together—us and the water, both—most people call a solution. If you break us up to get things more accurate however, then you call the water a dispersing medium and us a dispersed phase. Just because water is the most universal solvent, I don't want you to get the idea that you have to have water to have a dispersion. Fact of the matter is, dispersions may be gases, solids, or liquids. So much for the generalization—and now back to the family and me.

When chemists talk about Samuel, it usually sounds something like this. Suspensions are dispersions containing such large particles that they often appear cloudy and will settle out if left unagitated for a sufficient length of time.[1] And when they speak of Tessie they say; a true solution is a molecular dispersion that will never settle out, and they call the dispersing medium the solvent and the dispersed phase the solute.

As you might know, the chemists have their definition for me and have worked pretty hard to figure out just how I fit into the family. When they got it all thought out, some of them summarized it rather concisely, so I'm going to quote for you just exactly what they said about me.

> "Intermediate between true solutions and true suspensions, and merging into both, is a class of substances which consists of particles too small to be filtered and yet too large for a molecular dispersion of a true solution. Being so small, the particles are in continual motion and only settle out when compelled to do so by chemical or mechanical means. Such a dispersion as has just been described is called a colloidal dispersion, and the substance dispersed is called a colloid."[2]

My name is of Scotch origin and its just a bit descriptive of me, too, because it means "glue-like." They've decided to give Thomas Graham, who lived from 1805 to 1869, credit for being the father of colloidal chemistry. Just between us though, I want you to know that I had been prepared and studied in the laboratory for a full century before his time. I must admit though that he did do more to make me known as I truly am than any of those who worked with me before his time.

This same Mr. Biddle that described me for you a few paragraphs back also put a nice little chart in his book showing how I compared with the rest of the family. He did such a nice job that I'm going to copy it for you right here, just in case you'd never get around to looking for it in Mr. Biddle's book.

Now I'll take you through my most outstanding character-

Comparison of Solutions, Suspensions, and Colloidal Dispersions[2]

Properties	Molecular Dispersions	Colloidal Dispersions	Suspensions
Approximate diameter of particles in millimeters ...	$\frac{1}{10{,}000{,}000}$ mm.	$\frac{1}{1{,}000{,}000}$ mm. to $\frac{1}{100{,}000}$ mm.	$\frac{1}{10{,}000}$ mm. to 1 mm.
Visibility	Impossible	With Ultramicroscope	With microscope or naked eye
Osmotic pressure	High	Low	None
Diffusibility and Filtrability	Passes through membranes and filters	Passes through filters but not through membranes	Does not pass through filters and membranes

1. The permanence of the suspension depends on the coarseness of the suspensoid; with the coarser suspensoid being the less permanent.

2. Harry C. Biddle, M.A., *Chemistry for Nurses*, pg. 96.

istics one by one and kind of explain some of my phenomenal tactics to you as I go.

Since all of my little particles are so small, I have a tremendous amount of surface. Being in so many pieces doesn't make me weigh a speck more but it sure gives me lots of drawing power I'd never have if I was in larger pieces. If I were a metal, I suppose they'd say I had magnetic powers. It just so happens that "adsorption" is the name they have attached to my ability to attract other substances to my surface. They utilize this characteristic in every thing from making carbon gas masks, to adsorbing poisonous gases, to purifying medicine.

I have another little activity known as my "Brownian movement." To see this in action you might almost conclude I was alive, but I'm not. I am in constant motion when observed through an ultramicroscope. Mr. Taber, in his medical dictionary, points out the difference in my movement and that of living material by saying mine is "oscillatory movement distinguished from self-motility of living microorganisms." What he's trying to get across is that my movement depends on the electrical vibrations within my particles while a substance that is alive moves under its own motivation.

My Faraday-Tyndall effect I think is quite interesting and you'll be amazed what an important part it plays in your enjoyment of the world around you. If you pass a light through a dispersion and you can follow the light beams then you know that you've just passed through a colloidal suspension. If you can't follow the path of the light beams, then your light is shining on some member of my family—and not on me.

Now for a moment's digression while I admit my limitations. I simply cannot undergo osmosis;[4] my particles are too large to pass through a semi-permeable membrane. There is a way of separating me from crystalloids, however. Scientists call it dialysis, and it's a process of diffusing a crystalloid through a membrane to remove it from a colloid. It might be well to clarify this by explaining that "crystalloid" and "colloid" do not refer to matter as such but to states of matter.

I'm a regular little imbiber and just like people who are, I cause a lot of trouble sometimes because I refuse to give up the habit. A protein colloidal dispersion will imbibe water until it swells many times its normal size. We call this little habit "imbibition" and just between us, I don't know of anyone else who can do the same thing in the way that I can do it. Lots of your little headaches and other aches and pains are caused by pressure on a nerve somewhere just because I felt injured and started imbibing again.

You've gotten the general facts now as to my over-all characteristics. Next I'd like to show you what these particular habits of mine mean to you as an individual. There are unlimited places where I exist and consequently, I had an unlimited field to choose from to demonstrate my properties in action. I thought about telling you how important I am to you in foods, because I'm in everything you eat. Later, I considered letting you know about my importance to you in your dress. Finally, I gave some attention to pointing out my usefulness in housing. Then I reconsidered —food, clothing, shelter—I am in all of these things, but yet I did not have just what I wanted to talk to you about.

4. Osmosis is the passage of a solvent from an area of lesser concentration to an area of greater concentration through a semi-permeable membrane.

My final decision rested on something that should be very dear to your heart. In fact, the very substance which fills your heart and keeps your body operating proved to be the topic that I thought would most appeal to you. From here on in, I'll be telling you about your blood and demonstrating for you how each of my properties is of significance to your well-being in life from the point of view of your circulatory system.

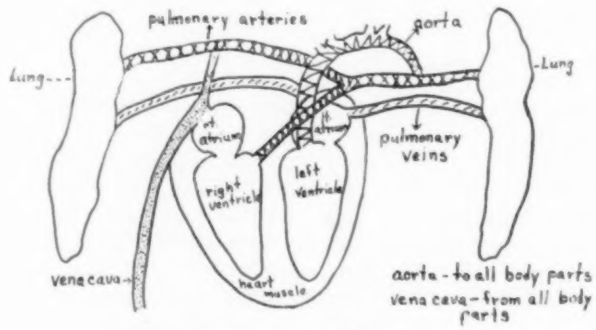
I guess the fairest way to evaluate the abnormalcy of the situations we're going to discuss is to give you an idea of the normal regarding your blood.

Normal Blood Constituents[5]

Blood	Cells	Red blood cells (erythrocytes) White blood cells (leukocytes) Platelets
	Plasma	Water Gases Foods Blood proteins Salts Protective substances Hormones Waste

The two great divisions in the blood are the cells and the plasma. The normal constituents of each division are briefly listed above. There are continual changes occurring in the circulatory system, but only those which are pronounced and enduring are of particular significance to us right now.

You know, I really run a pretty thorough course throughout your entire body in my liquid colloidal state. I'm not what most folks would consider an artist, but I'll give you an idea of the path I follow in your body.



PATH OF THE BLOOD.

This diagram shows the major veins and arteries which the blood passes through from the time it leaves the heart until it returns to the heart again.

Only part of the blood is truly a colloidal dispersion. We have already designated that blood is composed of the two

5. Biddle, *Chemistry for Nurses*, p. 310.

chief divisions of cells and plasma. Plasma forms 55% of normal blood and is a true colloidal solution. Even the formed elements in plasma do not settle out because of the constant agitation from the beating of the heart. The other 45% of the blood is composed of the three types of cells. Of these the red blood cells and the platelets are true colloids. They never settle out nor pass through the walls of the blood vessels. However, the white blood cells are not colloids. They come and go through the walls of the blood vessels as they are needed in various parts of the body to fight infection—which is their chief job. A normal adult body weighing approximately 150 pounds contains an average of five quarts of blood.

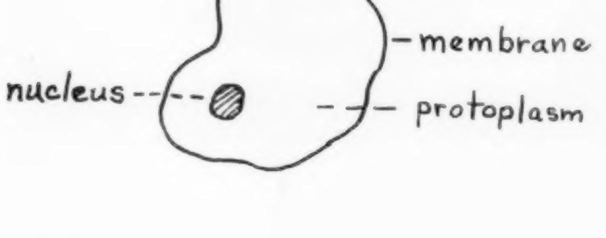
We will now take the previously mentioned characteristics one by one and point out the vital importance of each to your life.

Early in this autobiography I mentioned the fact that true colloids do not settle out even though they are under no agitation. Do you know just how important that is to you? Just suppose you'd been working pretty hard all day. Evening comes and you decide to settle down in your nice soft easy chair for a bit of relaxation and maybe a nap. Wouldn't you be alarmed if on awakening after about an hour you were to find that all the outer surfaces of your body, where there is very little blood pressure, were pale and colorless because the red cells had all settled out from lack of agitation? That won't happen—so relax when you can. Once a colloid; always a colloid; and I'm true blue to my nature. I'll never settle out and leave you all pale on the outer surfaces—I promise!

Then there is this little matter of osmosis. You will remember that it was one of my limitations because I'm too big to get through a semi-permeable membrane. Every day as I see crystalloids of food particles being diffused into my blood stream and carried to all parts of the body, I say "Thanks, God, for making me a colloid." I really like it right here in my nice warm red blood stream and am perfectly happy that I can't be pulled through the walls of the blood vessels by osmosis. This knowledge makes me feel so secure—no danger of losing my happy home!

Blood is one of the millions of colloidal dispersions that is chiefly water. Whole blood is 80% water, 18% proteins, and 2% other solutes. Plasma is 90% water and contains various solutes.

I've been looking for a place to draw you another picture and I think this would be as good of time as any. I want you to know the general structure of a cell. I could draw you just about any shape and have it be some form of either a red or white blood cell. They are extremely variable in size and shape, but they all have this same general structure.



Scientists have tried hard to make some in the laboratory but have been entirely unsuccessful. Living right in protoplasm all the time, we're intimate friends and I know all there is to know about him. But I'm a loyal sort of a little fellow. We colloids don't tell all we know. You human beings have to find things out for yourselves because you can't call it a law until you can prove it anyhow, so you'd sure never settle for anything on the testimony of one little colloid.

I'll tell you a little bit about each of these types of cells that go to make up blood. The white cells, which aren't colloids, number from five to nine thousand in normal people, but I wish you could see those fellows multiply when a disease organism gets inside the body they're giving their life to protect. They usually live only about twenty-four hours, but they're manufactured as fast as they are destroyed or die, if you're in normal health.

The red blood cells, true colloids, are manufactured in the red bone marrow and maintain a dynamic equilibrium. They live a pretty long time in comparison to their fellow cells. They average from 25 to 50 days, but some of the old diehards can manage to hang on for about 100 days.

Platelets are the third and last type of blood cells in a human body. They enjoy a life span of from three to five days. I always enjoy telling people about the following discrepancy because they begin to think they're having optical illusions. Red blood cells by themselves are not red at all. They are a straw yellow, and only when they appear in large numbers do they exhibit a red color.

The red blood cells are pretty small—3,000 cells per inch. They're mighty numerous though—about four to five million in an average adult, and they make up about 6% to 8% of the amount of the blood by weight.

Plasma is a rather elusive fellow. After all these centuries of human beings who contained such large quantities of the substance, the exact chemical composition is still unknown. Another one of those little secrets among us colloids!

In the body there are some excellent examples of the ability of colloids to change from a sol to a gel and back again. It goes on continually in the muscles. Every time a muscle contracts the colloidal protein turns to a gel and when it relaxes it returns to a sol. Then there comes a time in the life of every one of us when our muscles turn to gel for the last time. We colloids call it a state of irreversible gel of a colloidal dispersion, but the morticians seem to think it sounds better to call the same state "rigor mortis."

Reversible states of sol and gel are continually being enacted in the protein molecules of protoplasm. This characteristic is responsible for the unique "aliveness" of protoplasm. Only under abnormal conditions produced by heat or chemicals do these protein molecules enter an irreversible state. When this happens death is the inevitable result unless medical treatment can alter the situation within a limited period of time. To give you an idea of the rate of speed at which some of these reactions are occurring in your blood stream, I'll tell you that the blood proteins of which we were just speaking are completely replaced every 20 days. Next time that long departed friend meets you

(*Continued on Page 157*)

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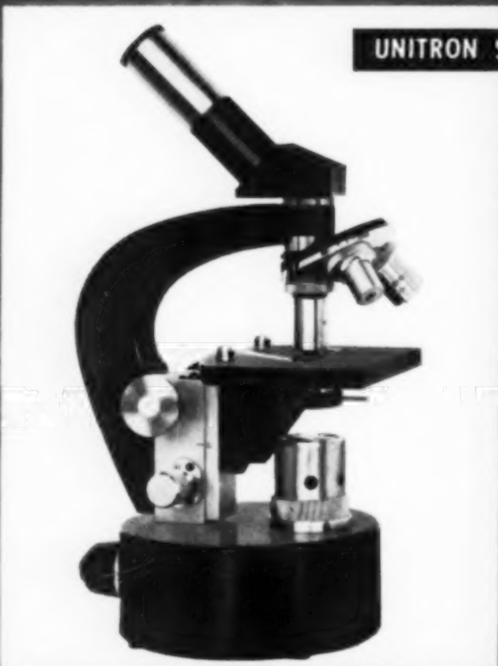

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Mathematics and Poetry

• **Charlotte Melcher, A.B.** *Marygrove College*
PENSACOLA, FLORIDA

A consideration of the aesthetic structure of mathematics and the affinity of mathematics and poetry.

In considering the relations of the arts and the sciences, the relationship of the arts to mathematics should not escape us. The first question which arises is whether any similarity exists. We would not be the first to ask what "cold, calculating mathematics have in common with subtle, creative, lofty, imaginative art." Yet mathematicians have frequently asserted that "the object of their pursuits is just as much an art as it is a science."[1] To them mathematics is a revelation of the beautiful structure of nature through abstraction; it is the result of an effort to create order and beauty.

To one who has studied mathematics, not merely as a tool nor as a series of manipulations, but as an integral whole composed of many fascinating, harmonious, and complementary parts, mathematics communicates, in the manner of art, truths and insights into realities beyond the physical world. It possesses, moreover, a striking similarity to the art of poetry in particular, for the creation of both is highly intuitive and both make use of such vehicles of expression as symbolism and symmetry. Both contain ideas far greater than their expression would imply, and indeed, both are difficult to really understand.

Mathematics is said to be the exact and exacting science of logic. This is true. Yet Marston Morse has penetrated beyond the externals of this element of logic when he says, "The creative scientist lives in 'the wilderness of logic' where reason is the handmaiden and not the master,"[2] for logic is the tool, not the essence of mathematics. The whole of mathematics is much more vast than mere logic. It contains a beauty consisting in unity, proportion, and harmony comparable to those of art. The very orderliness and logic of mathematics demand these qualities, and from them arise the elegance and sophistication typical of a fine mathematical system.

The unity and proportion of mathematics are obvious. In a mathematical system inconsistency amounts to disproof. In a particular problem, the working towards a goal and its achievement in as concise and elegant a manner as possible are of the essence. Deviations or the use of unnecessary unrelated materials has no place.

The harmony of mathematics is perhaps a little less easily seen, for it encompasses many apparently unrelated or disunited aspects. Yet between the various areas exist meeting and fusion points so complete as to give rise to another branch, as is the case with geometry, algebra, and analytic geometry.[3] As Coleridge has said of poetry, the parts mutually support and explain each other.[4] Not only are they harmonious among themselves, but all are functions of a harmonious whole. The many systems of geometry can be considered as special instances of one harmonious system.[5]

Poincaré, the famous mathematician, summarizes these ideas. "It is the harmony of the different parts, their symmetry, and their happy adjustment; it is, in a word, all that introduces order, all that gives them unity, that enables us to obtain a clear comprehension of the whole as well as of the parts."[6]

The mathematician works with a unit possessing the qualities of formal beauty. But these are given impetus by the concept itself. The mathematician's works are discoveries of pre-existing truth, of inherent order. They are an expression of a vast and universal abstract relationship above and beyond particular things. Mathematics is concerned with the understanding of the infinite network of relations within a cosmic whole, with the discovery of invariant forms of reality, with the understanding of the baffling nature of infinity.[7] The mathematician works with ideas, significant ideas characterized by generality and depth, and expressed within mathematical systems possessing the characteristics of formal beauty previously described.[8]

There are those who would insist, however, that mathematics is not autonomous and has no right to be considered in this manner, for it is the tool of the sciences. Obviously there are many important practical scientific applications of mathematics. These are by-products, however, illustrating its value although unsought and unnecessary. The realization of this fact by mathematicians is evidenced by J. J. Sylvester, for when questioned as to the purpose of the theory of substitution groups, he replied, "I thank God, that so far as I know, it hasn't any."[9]

Since mathematics does not exist for its applications, we may look deeper into its essence in order to find its value, its creative possibilities, and the communicability of its truth and beauty.

Mathematics is the oldest science, yet the concepts of modern mathematics were undreamed of by the ancients, for the mathematician is a maker of patterns and the number of possible patterns is infinite. The mathematician's choice of pattern is governed not only by logic, but by a feeling or intuition which enables him to guess hidden harmonies and relations. Those ideas which most affect this special sensitiveness are those which break through to his conscious mind. His intuition acts as a sieve, preventing imperfect or unappealing combinations from entering his conscious mind.[10]

The working of the creative intuition of a mathematician can be compared to that of a poet. Jacques Maritain has expressed creative intuition in poetry as "an obscure grasping of the poet's own Self and of things in a knowledge through union . . . which is born in the spiritual unconscious, and which fructifies only in the work." To him poetry

itself is but a ". . . particular flash of reality bursting forth in its unforgettable individuality but infinite in its meanings and echoing capacity."[11]

In a similar vein, the mathematician Gauss explains the birth of a particular theorem which he had put aside after working on it unsuccessfully for two years. "Like a sudden flash of lightning, the riddle happened to be solved. I myself cannot say what was the connecting thread."[12] Is this not the working of the subconscious or the intuition, searching for a combination of ideas which embodies, despite its individuality, an infinity of meanings?

The products of mathematical creation contain, not only the intellectual and imaginative appeal commonly granted to them, but appeal to the emotions as well. To deny the emotional appeal of mathematics is to "forget the feeling of mathematical beauty, of the harmony of numbers and forms, of geometric elegance. This is a true esthetic feeling that all real mathematicians know, and surely it belongs to emotional sensibility."[13]

This emotional sensibility is induced by the symmetry and arrangement of mathematical symbols, by the pregnancy of the symbols themselves, by the rhythm of symmetric expression. It is, as Shelley says of poetry, the reproduction of materials of knowledge, power, and pleasure according to a certain rhythm and order.[14] This general meeting of the functions of mathematics and poetry can be seen in particular aspects of each.

"One merit of poetry," for instance, Voltaire has said, "is that it says more and in fewer words than prose."[15] No one will deny that poetry captures and conveys meanings too great for any exacting or prosaic explanations. Indeed, the poet sees and brings others

> To see the world in a grain of sand,
> And a heaven in a wild flower.[16]

Similarly, mathematics is often called the very "essence of brevity."[17]

Another characteristic of poetry is the symmetry of its verses, both on the written page and within the actual poem. Its counterpart is found in the symmetrical arrangement of mathematics. Its arrangement on a page presents a rhythm of symmetry to the eye, and within the content is a natural balanced flow. Consider, for example, the equations for the circle, sphere, and hypersphere, in progression:[18]

$$x^2 + y^2 = r^2$$

$$x^2 + y^2 + z^2 = r^2$$

$$x^2 + y^2 + z^2 + w^2 = r^2$$

The use of symbolism as found in poetry in imagery, similies, personification, and the like, is paralleled by the use of symbolism in mathematics. Even its language is that of symbols, although this in itself is often a deterrent to the recognition of the artistic content, for the mastery of mathematical language is no mean accomplishment, and too often it leads to a case of not seeing the forest for the trees. Beyond the symbolism of the language, however, lies the symbolism of the symbols themselves. For example, set theory requires a mastery of the symbols and algebra of sets. Yet once these are under control, there unfolds a deeper and more wonderful symbol. The highly intuitive concept of set at once illuminates a beautiful ordering of ideas, both in a "mathematical" sense, and in a sense far beyond any particular representation and penetrating into infinite reality.

The simultaneous occurrence of symbolism and symmetry and the aesthetic content would in itself demand a natural, flowing rhythm, that which mathematicians would like to call sophistication or elegance. They are not content to merely prove theorems or carry a system to its logical conclusion in any fashion. Indeed, many proofs accepted as true and complete are worked and reworked simply because they lack aesthetic appeal. Then in a finished and polished form they delight and excite the reader for the natural flow and ease of the rhythm within.[19]

Is this not also true of a poet, who, having worked long and arduously, on a poem, produces a work which has such a spontaneity of rhythm that one would think it had been written in an instant of inspiration.

There is, indeed, all this in mathematics. It is not available to those untrained in mathematical fields, nor even to many who know and love mathematics but remain apart from it, lost in a maze of manipulations. But such are not mathematicians. Mathematicians, in the fullest sense of the word, are those who have mastered mathematical techniques in all their objective qualities and gone beyond, to penetrate into the deeper relationship between mathematics and reality and truth. These men have penetrated into the essence of art, and found delight in its creation and expression. They have felt great truths and expressed them, which is the role of the poet.[20]

Could we not agree wholeheartedly with Weierstrass, then, when he perceives this relationship of mathematics and the arts, to conclude that in order to perceive, to intuit, and to love all that is contained within mathematics, one must also be somewhat of a poet.[21]

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(Continued on Page 135)

Flowers for Teens

(Continued from Page 124)

grouping. Choice of background consisted of a stone wall painted a luscious bittersweet shade, or an oak panelled wall. The illustrations show that the stone wall was preferred, the color no doubt being the decisive factor. Further comment on the photos is unnecessary. In them you can see, as the students did, the good and bad points of their efforts. The pictures are unposed. The students were too absorbed in their tasks to pay attention to a flash camera. They did know, however, that pictures were being taken for use in an article for possible publication. Nothing more was done on classtime. The one arrangement by each group completed the assignment.

Evaluation of the unit in appraising student achievement came later. The teacher of this problem, acting in her capacity of Sophomore Advisor found evaluation an easy matter in subsequent assignments and social activities, pictures and an account of which is matter enough for a "sequel."

Subsequent Assignments

Series of arrangements for a specific location—this was an optional activity, nevertheless every member of the class participated. (Figs. 12, 14.)

Vegetative propagation—sweet potato—these came to class in original, unique containers, rather than the customary fruit jar or tin can. One student brought two because she wanted a "symmetrical arrangement for above the fireplace."

Plants in Christmas decorations—every conceivable combination from stark modern to Della Robbia wreaths. The latter was used as the focal point of gym decorations for a Christmas dance.

Flower show—staged during the annual meeting of the Conference of Secondary Teachers, produced—period pieces, Colonial, French, Victorian, Flemish; tea cart, coffee and occasional table settings.

Social Activities

The annual Cotillion (top event of the season) escort to which is her best beau, Dad, *not her* Beau Boy—decoration theme, Colonial Williamsburg—authentic to minutest details, flower arrangements duplicates of those used in the Governor's Palace 18th century. Heirloom containers, glass epergnes with rose buds and bayberry candles, iron candle molds, Paul Revere silver urns. A close scrutiny of the photos of these social events (not reproduced here because the committee felt it too expensive) shows a definite development in the class of a real love of flowers and the ability to arrange them charmingly. Nor does the evaluation end even at this point. The freshmen were observing. This year as sophomores they—but that is another story.

Mathematics and Poetry

(Continued from Page 133)

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Computer to Analyze Human Heartbeat

A method has been developed for using high-speed computers to analyze and compare heartbeat information. By use of this method, a physician can be helped in making an objective diagnosis of his patient. The method will also help in making statistical studies needed to establish more accurate limits for normality. In an analog-digital converter, electrical signals associated with heartbeats are converted from continuous waveforms to digital form on magnetic tape, which is then used in a computer for comparison either with a normal record for diagnosis or with a group of records for statistical purposes. The cardiac cycles of approximately 1,000 patients may be recorded on one reel of digital magnetic tape, and the system can be expanded to include additional clinical data. The eventual goal is to combine a diagnostic computer program with the analytic program—a combination which should become a powerful tool for studying heart diseases.

* * *

The National Foundation, supported by the New March of Dimes, Jan. 2–31, conducts the largest virus research program of any voluntary health organization in the world. The Salk vaccine came from these researches.

Flowers for Teens

(Continued from Page 124)

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Subsequent Assignments

Series of arrangements for a specific location—this was an optional activity, nevertheless every member of the class participated. (Figs. 12, 14.)

Vegetative propagation—sweet potato—these came to class in original, unique containers, rather than the customary fruit jar or tin can. One student brought two because she wanted a "symmetrical arrangement for above the fireplace."

Plants in Christmas decorations—every conceivable combination from stark modern to Della Robbia wreaths. The latter was used as the focal point of gym decorations for a Christmas dance.

Flower show—staged during the annual meeting of the Conference of Secondary Teachers, produced—period pieces, Colonial, French, Victorian, Flemish; tea cart, coffee and occasional table settings.

Social Activities

The annual Cotillion (top event of the season) escort to which is her best beau, Dad, *not her* Beau Boy—decoration theme, Colonial Williamsburg—authentic to minutest details, flower arrangements duplicates of those used in the Governor's Palace 18th century. Heirloom containers, glass epergnes with rose buds and bayberry candles, iron candle molds, Paul Revere silver urns. A close scrutiny of the photos of these social events (not reproduced here because the committee felt it too expensive) shows a definite development in the class of a real love of flowers and the ability to arrange them charmingly. Nor does the evaluation end even at this point. The freshmen were observing. This year as sophomores they—but that is another story.

Mathematics and Poetry

(*Continued from Page 133*)

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Computer to Analyze Human Heartbeat

A method has been developed for using high-speed computers to analyze and compare heartbeat information. By use of this method, a physician can be helped in making an objective diagnosis of his patient. The method will also help in making statistical studies needed to establish more accurate limits for normality. In an analog-digital converter, electrical signals associated with heartbeats are converted from continuous waveforms to digital form on magnetic tape, which is then used in a computer for comparison either with a normal record for diagnosis or with a group of records for statistical purposes. The cardiac cycles of approximately 1,000 patients may be recorded on one reel of digital magnetic tape, and the system can be expanded to include additional clinical data. The eventual goal is to combine a diagnostic computer program with the analytic program—a combination which should become a powerful tool for studying heart diseases.

* * *

The National Foundation, supported by the New March of Dimes, Jan. 2–31, conducts the largest virus research program of any voluntary health organization in the world. The Salk vaccine came from these researches.

Radioactive Isotopes in Medicine

• By Dr. Henry A. Rothrock
CHESTER COUNTY HOSPITAL, WEST CHESTER, PA.

This paper was presented at the Pennsylvania Catholic Round Table of Science meeting at Immaculata College, Immaculata, Pennsylvania, April 11, 1959.

●

Since World War II, radio-active isotopes have become important in our everyday life. We have learned to use these isotopes for the good of man and in a manner that is both safe and advantageous. In the practice of medicine these isotopes were first used to gain more knowledeg of body chemistry and physiology. As more work has been done, we now find these chemicals being used to aid in the diagnosis of disease. These isotopes have become very useful in following chemical compounds and elements through the complicated pathways of the chemistry of disease. These isotopes also makes a very accurate method of quantitative measurements of different areas of normal and abnormal physiology.

The measurement of plasma and red cell volume of blood in many cases is of great aid in the treatment of the disease Our blood counts measure the proportion of red cells to plasma. This is an aid in many cases, but it does not tell us how much blood a patient actually has. By incorporating radio-active iodine in the plasma protein molecule, we can inject a known amount of this tagged protein into the blood pool. Then by measuring the radio-activity of the plasma and by the simple mathematics of dilution we can measure the total volume of the plasma and red cells in the patient's blood stream. Radio-active chromium can be introduced into a sample of red cells and this can then be injected into a person's blood stream. We then, by serial measurement of the radio-activity of the blood measure whether the life span of the patient's red cells is normal. This is an important aid in the study of certain anemias. We are able to introduce radio-active iron into the blood stream. We then are able to follow this iron through the metabolic process of hemoglobin formation and its rate of introduction as hemoglobin into the red cells.

Radio-active iodine can be introduced into the glycerol trioleate molecule. When this compound is then taken by mouth the pathway of fat digestion and absorption can be traced in the patient to aid us in the diagnosis of certain forms of pancreatic, gall bladder, and mal-absorption abnormalities.

The function of the thyroid gland can be studied by administering radio-active iodine to a patient, then measuring the quantity of radio-activity picked up by the thyroid gland. Further studies of thyroid metabolism can be followed by measuring the proportion of the iodine that is bound to protein by the thyroid.

We see in these methods valuable additions to our methods of diagnosing disease and following the benefits of treatment. The sensitivity of our modern equipment has made these measurements safe to be carried out as routine procedures. The tracer doses that are used are so small that any untoward effects on the patient have been eliminated. With our increased knowledeg the use of radio-active materials will increase. Methods worked out in our research are rapidly becoming available to the physicians in our communities to enable them to better treat and diagnose disease.

★ ★ ★

Science Clubs of America Sponsors Handbook

This is a unique guide to discovering and helping young student-scientists.

A compact manual of pertinent information, revised annually to include new developments and current data, it is supplied free by Science Clubs of America to the sponsors of some 25,000 affiliated clubs all over the world. Since the book has proved interesting and helpful to other educators, parents and organizations, it also has been made available for purchase at $1.00.

This 1960 edition, just off the press, is considerably enlarged and includes features designed to meet current needs and questions. For example, information is given on effective ways of encouraging development of the abilities of science-prone students, summer science opportunities, research projects for student-scientists, and nationally available scholarships.

Details are supplied on science fairs and how to run them; how clubs may carry out co-projects with national agencies; how high school seniors can participate in the Science Talent Search for the Westinghouse Science Scholarships and Awards; and the location of groups affiliated with Science Clubs of America.

Materials and ideas for club programs, classroom demonstrations and exhibits; sources of hard-to-find scientific equipment and supplies; unusual samples; film and book lists; maps; wall charts; pamphlets and instructions are some of the helpful items listed in the enlarged section of free and low cost science materials offered by hundreds of industrial and professional organizations who cooperate with Science Clubs of America.

The book may be ordered from Science Clubs of America, 1719 N Street, N.W., Washington 6, D. C.

Colloids

(*Continued from Page 129*)

with the statement, "It's been so long; you are almost like a new person"; you come right back and say "What do you mean, almost?" My little colloids have been functioning right along and I am a new person." Careful who you say it to though—they might not understand us colloids and our chemistry!

Imbibition allows us a lot of liberty. Protoplasm has the ability to keep right on imbibing until the cell is three-fourths imbibed liquid by weight and still is in a solid state. Can you beat that for really "taking it in"?

I've shown you nearly all of my main characteristics at work in your blood stream. As you all know, there are various diseases and pathological conditions which upset any or all of these normal functions. The changes produced by pathological organisms and the manner in which they upset the normal action of a colloid is a study in itself which I'm not going into at the present time. I'm only admitting to you that I don't always function just the way I should and maybe at some future date we can get together again and show you all my abnormalities.

Please understand that I take no credit to myself for my ability to perform the phenomenal and extraordinary functions that I have pointed out to you. I am a creature of God that functions only as He wishes me to function. I live out my life exactly according to his plan, because not being endowed with a free will I am unable to act in any manner other than God ordains. Therefore, I am freed from the necessity of choosing between right and wrong with which you human beings are confronted. I promise to do my part according to God's designs to help you fulfill the plan He has set for you by keeping your body in the best health for you.

After all your body is the companion of your soul and I would like to see the Light of Glory shining through each little colloid in your glorified body in eternity. Please don't let me down. I'm doing what I can to help you gain God for all eternity.

Good-bye now and God love you—from here to eternity!

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For Better Living . . .

The items listed below are either under consideration or are presently on the drawing board.

Cordless electric clocks that will have no moving parts yet will be accurate to the split-second. Clock will use an electronic circuit based on transistors.

•

Transistor radios run by solar power. And pocket radios about the size of a watch.

•

For the home: plug-in wall panels that will heat or cool air. Employing phosphorescent materials the panels will also glow when energized by electricity.

•

Battery operated TV sets. Batteries will be rechargeable from an electric outlet. TV sets that can be hung on the wall.

•

With a possible water shortage confronting the nation, chemists are researching methods to obtain fresh water from sea water. A de-salting plant to be built shortly will utilize "plastic membranes" which permit water to pass through but not salt. Plant will de-salt brackish well water.

•

A nitrogen writing pen. Atmospheric nitrogen, combined in controlled amounts with a solid chemical compound, would produce the writing fluid.

•

Use of magnetic tape instead of film for the home movie camera. Such tapes could be viewed on a home television receiver. Tapes could be erased, reused as often as needed.

•

Atomic power may one day be used to mine the sea.

Chemical News

New Books

Studies in Mathematics Education

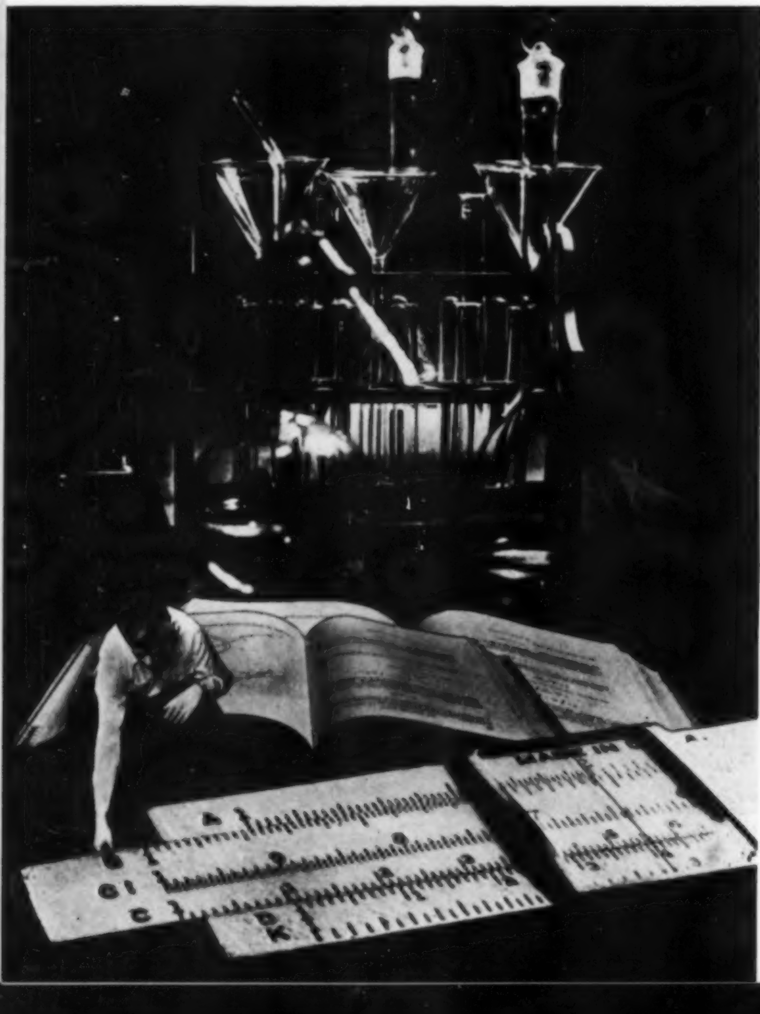
• Scott, Foresman and Company, Fair Lawn, New Jersey, 1959. Pp. 57. $.50.

Before new ideas in the area of mathematics education can find their way into the curriculum of a school there must be new understandings on the part of the teachers. These new understandings may come from in-service training, graduate study, independent research or various other sources. This concise report of recent studies in the area of *mathematics education* gives to the teacher an excellent source for coming abreast of the latest thinking and findings in the field.

The studies in this booklet are described sufficiently to give the reader the basic details. Each study has the address of the person or organization to whom further inquiries are to be sent. While some of the studies are completed, others are still in progress and will report more information as it becomes available.

Studies included range in interest from kindergarten programs to college mathematics and are conducted by teachers in all levels of *mathematics education*. Some studies are concerned with rather small geographical areas while other investigations deal with the entire United States. This aspect lends itself equally well to individuals who are interested in improving local curriculum, as well as those who are attempting to get insight into problems of national scope.

One very valuable part of the book is that it identifies organizations which are active in supporting studies in the area of *mathematics education*. This provides an opportunity for educators interested in taking an active part in some phase of *mathematics education* to secure information relative to financial assistance.



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Modern High School Biology—A Recommended Course of Study

• *By* Dorothy F. Stone. Bureau of Publications, Teachers College, Columbia University, New York. (Science Manpower Project Monograph) 96 p. 1959. $1.50.

The *Modern High School Biology* monograph includes an interesting outline for a suggested course of study in high school biology. Units are designed to serve as a guide to implementation and supplementation of courses of study currently in use in general biology or for use in their entirety.

The outline is an outgrowth from criticism leveled at our present biology courses. "Although not the fault of the traditional courses in biology per se, the tight spiral produced by the inherent nature of isolated science courses has resulted in tedious repetition of biological topics in the elementary school, again in general science, yet again in general biology, and to a varying degree even at the college level."

The booklet is divided into four general categories:

1. Introduction—including criticism of the present course and general approaches to a modern course.
2. Organization—including explanation of the suggested outline of study.
3. Course of Study—including detailed course outline supplemented by appropriate explanations.
4. Implications—including suggestions for general teaching methods, laboratory equipment and experiments.

The course of study explained in detail is subdivided into six units as follows:

1. Chemical and Physical Aspects of Life
2. Structure and Function of Living Things
3. Intra- and Interdependence of Life
4. Reproduction
5. Genetics
6. Changing Things

As the reviewer analyzed the course outline, he was impressed with the inter-relatedness of the various sciences that the course suggests. Topics reoccurring within general outline headings would offer an opportunity for the student to observe these inter-relationships. These topics, while broad and practical, contain much depth. The suggested course, comprehensive in coverage, assumes an excellent background in physics and chemistry. If the present outline were to be used in its entirety at the tenth grade level, a more cumulative, more demanding science program in the elementary school is necessary.

A list of the necessary laboratory equipment and the appropriate laboratory experiments can be found in a section of the monograph. For the average school of average means, the equipment appears too costly. The experiments, more advanced than the traditional type, demand not only a most able student but also a most able teacher well versed in specific subject content.

The *Modern High School Biology* monograph concentrates upon a smaller number of comprehensive understandings, inter-relates the various sciences by means of a unifying theme, and broadens the biological principles ordinarily

considered in a text at this level. Every biology teacher can benefit from the suggestions in the booklet, but more important, the monograph sets the stage for a tremendous effort on all fronts to revamp our science curriculum so as to include a more integrated, more intensive, more cumulative, and more effective approach.

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Careers in Science Teaching

• *By* THE NATIONAL SCIENCE TEACHERS ASSOCIATION. 1201 Sixteenth St., N.W., Washington, D. C. Single copy, free: quantity orders, 10 cents each.

Because the great battle of our times involves the question of survival, priorities in the subjects of the curriculum become important to both students and the nation. Perhaps the most pressing priority in public education is the improvement of mathematics along with the physical and biological sciences through better teaching programs.

This little booklet (about 20 pages) examines the work of the science teacher with the view of recruiting qualified students for a career in science teaching. Authentic data are provided on such topics as the nature of the work, job opportunities, financial returns, the personal and professional qualities needed by prospective science teachers, as well as personal benefits and professional responsibilities.

Altogether it makes an instructive and inspirational little manual for those who seek guidance in the selection and pursuit of science teaching as a career.

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Science and Human Values

• *By* J. BRONOWSKI. Harper Torch Books/The Science Library. New York. 1959. Pp. 94. $0.95.

It would be a tremendous task to adequately and justly review this scholarly study of science and human values. It is well written, carefully thought out and the author's views are well argued. It should be studied and not just read.

The argumentation is characterized by a studious avoidance of metaphysics and by a use of the scientific method in areas beyond its scope. Those who have trained in metaphysics will find many challenging statements in this little book of 94 pages. The book contains three chapters, the first is "The Creative Mind," the second, "The Habit of Truth," and the last, "The Sense of Human Dignity." There is much that is debatable in all three essays.

While the author is fair in his evaluations, his views seem to be colored by the opinion that anything that happened before 1500 can be ignored. This prejudice would seem to explain why he makes excellent use of the principle that there is nothing in the intellect that has not been first in the senses, while criticizing St. Thomas who used this same principle in his explanation of abstraction and the universal idea. Again he attributes to Coleridge the definition of beauty as "order in variety" and does not realize that this is the definition of beauty used by St. Thomas. He seems to have read *De Veritate* but has neglected the more basic works of St. Thomas Aquinas.

J. P. M.

Ancient Science and Modern Civilization

• *By* GEORGE SARTON. Harper Torch Books/The Science Library, Harper and Brothers. New York. 1959. Pp. 111. $0.95.

While this collection of three essays on the development of science in the Greek world from the ninth century B.C. to the fifth century A.D. is brief, it is by no means superficial. It is exceptionally well documented and presents an accurate picture of the science and culture of the Greek world from the beginning until its encounter with Christianity. It is scholarly in content, well written, and interesting to read.

This book can be highly recommended to beginners and scholars in science, classics, history, philosophy and the social sciences.

J. P. M.

The Chemical Elements

• *By* HELEN MILES DAVIS with revisions by GLEN T. SEABORG. Published jointly by Science Service, Washington, D. C. and Ballantine Books, New York. 1959. Pp. 198. $0.50.

This is one of those rare books that can be recommended to the high school student just starting the study of chemistry and the Ph.D. in chemistry. Its pages are full of valuable information on the chemical elements, that is up-to-date and well organized. In many cases the history of the discovery of the element is given by presenting a section from the original paper on the element, and the reader is given an opportunity to read selections from Bunsen, Vauquelin, Davy, the Curies, Gay-Lussac, Berzelius, Mendeleeff, Agricola, Priestly, Robert Boyle, Berthelot, Lavoisier, Ramsay and many other outstanding names in chemistry.

It would be difficult to find a better reference source on the elements from hydrogen to element 102, and best of all the price is only fifty cents.

J. P. M.

A Guided Tour Through Space and Time

• *By* EVA FENYO. Prentice Hall, Inc. Englewood Cliffs, New Jersey. 1959. Pp. 181. $3.50.

By means of an imaginary tour through space and time the reader is introduced to the concepts of modern physics, the constancy of the velocity of light, special and general relativity in an attractive and accurate manner. The young reader and the adult who seeks to obtain a qualitative concept of the theories of modern physics will find this book most informative.

The author provides the reader with an imaginary spacesuit, a telescope, an electron microscope, the ability to travel with the speed of light or to achieve complete immobility, and various instruments such as spectrographs, measuring rods, etc. While the presentation is imaginative, it is accurately written. The illustrations are delightful and help to clarify the text.

The author is a well-known Hungarian writer and theoretical physicist. We recommend her book for high-school and college libraries.

J.P.M.

The Origins of Oriental Civilization

• *By* Walter A. Fairservis, Jr. A Mentor Book, Published by *The New American Library.* New York. 1959. Pp. 192. $.50.

This book is a scholarly survey of the prehistory of Eastern Asia. In spite of the complexity of the subject and the lack of complete data, Walter Fairservis has produced a highly informative and readable book. Known facts are carefully and accurately reported, and where speculation is necessary the conclusions drawn are in harmony with the facts presented.

The major portion of the book is concerned with the archaeology of China, a chapter is devoted to Japan and another to the regions bordering China. It contains a number of fine illustrations.

We recommend this book to all who are interested in the Far East, and to those who are looking for a book that will give them an insight into the methods and limitations of archaeology and the procedures used in constructing a picture of a past civilization from the facts uncovered by archaeologists.

J.P.M.

Towards a New World

• *By* R. Lombardi, SJ. Philosophical Library, Inc. New York. 1959. Pp. 276. $6.00.

Towards a New World is not just another book pleading for Christian principles, but it is a vigorous discussion of the position of man today, his heritage from past generations, the circumstances peculiar to the modern world, and what steps must be taken to assure man's future. The main thesis is that in the teaching by Christ is contained the directives needed and that in following Christ we obtain all the advantages of the conflicting philosophies of our times and avoid the disadvantages.

Since 1945 Father Lombardi, the author, has been an outstanding preacher in Italy. Readers of this book will find that his popularity is not the result of oratory nor ornate style, but the result of sound scholarship in philosophy, history and theology. His style is simple and direct but at the same time provocative and cheerful.

J.P.M.

★ ★ ★

Revolutionary New Program In Teaching Elementary Arithmetic

A revolutionary new program for teaching elementary arithmetic which "represents the first truly significant step forward in arithmetic in almost a century" has now been developed, according to *The Catholic Educator,* monthly education magazine.

Writing in the November issue of the magazine, Dr. Marion U. Blanchard, of Fordham University, New York, says of the new program, that "its approach is one that could possibly advance the American system of teaching elementary arithmetic beyond that of any other nation."

Dr. Blanchard, who is assistant professor in the graduate elementary division at Fordham, states that the new program "is not only designed to equip the pupil for the accelerated programs in mathematics that he will inevitably meet in later grades, but it is also so clearly meaningful and simply organized that many pupils can actually teach themselves."

The Catholic Educator states that the new system is "revolutionary in its approach yet does not demand that its instructors become highly trained 'specialists.'" Nor does it place "prohibitive demands on school budgets for expensive materials and 'gadgets,'" the magazine adds.

Traveling Science Library for Elementary Schools

Students in 800 elementary schools in cities and towns throughout the nation will begin to enjoy science books of the kind heretofore circulated only among their older brothers and sisters in high school. Harry C. Kelly, Acting Director of the National Science Foundation, today announced a grant of $500,000 from the Foundation to the American Association for the Advancement of Science to extend the successful Traveling High-School Science Library to include 500 sets of 160 science books under a newly established program, the Traveling Elementary-School Science Library.

Books for the new traveling library have been carefully reviewed by scientists, educators, library specialists, and students for adaptability to the learning level of academically-talented students in the first to sixth grades, and to average students in the first to eighth grades. The 160 books represent all major scientific disciplines, including mathematics. An accompanying catalogue classifies the books at three levels of difficulty—"P," primary or very simple; "I," intermediate; and "A," advanced. The AAAS plans to circulate 80 books (two boxes of 40 each) at a time to each of the 800 schools with an exchange at mid-year.

"The NSF-sponsored traveling science library programs typify the vast benefits which derive from cooperative public-private endeavor," said Dr. Kelly, in commenting on the new project. "It seems to me important to remember that in the final analysis the parents of school-age children support these traveling science libraries through appropriations made by the Congress to the National Science Foundation. These public funds, in turn, are entrusted to the AAAS many of whose member scientists have worked together with teachers, school librarians, and students, to select carefully the best science books available for libraries. The nation's book publishers have provided complimentary copies of their books which provide the reference collection from which the library books were selected.

"The productive results of this cooperative effort are several and significant—good reading habits are developed in the students' early years; the program recognizes and acts upon uncontested statistics which show that a majority of the winners of science-talent-search awards acquire their science interests before they finish the sixth grade; the program not only fulfills our own national objective toward stimulating increasing numbers of children to consider the rewards of careers in science, it is, as well, attracting interest in other nations—libraries have been sent to several United States military and diplomatic bases all over the world for the benefit of children living at such missions, and the Asia Foundation has sent two pilot sets of the books for use in Japan, and four more for use in North Borneo, Vietnam, and Singapore; finally, and importantly for the NSF, the program helps meet the Foundation's responsibility "to encourage the pursuit of a national policy in education in the sciences."

The Traveling High-School Science Library will this fall

(*Continued on Page 144*)

Traveling Science Library

(*Continued from Page 143*)

begin its fifth year, having been instituted in the school year, 1955–56, with 11 sets of books which circulated to 55 high schools. This year the library contains 465 sets of 200 books and will reach 1,700 schools. The 1959–60 selection consists of 165 books that were in the library during previous years and 35 new selections, necessary because books became unavailable for purchase.

As a result of its experience with the traveling school libraries, the American Association for the Advancement of Science found that the program had provoked wide interest among adults. *An Inexpensive Science Library*, a selected list of paperbound science books, now in its third edition, testifies to the popularity and usefulness of the two previous editions. A first edition of 24,000 copies issued in 1957 and a revised second edition of 50,000 copies issued in 1958 are both out of print. The present edition contains a brief descriptive note for each book which assists the prospective reader and purchaser in making selections, and a classification of each title according to degree of difficulty. The edition lists 400 titles.

The AAAS, with support from the National Science Foundation, has this year issued a new catalogue, *The AAAS Science Book List*, containing 900 titles. The new book is a guide to recreational and collateral reading and to basic reference works in the sciences and mathematics for junior and senior high school students, college undergraduates, and nonspecialist adults. It also serves as an acquistion guide for school and public libraries. United States book publishers provided complimentary copies of all books on the preliminary list which was then circulated for review and evaluation to members of the AAAS Council, representing each of the scientific organizations affiliated with the AAAS. Each citation contains a brief descriptive note and designation concerning degree of difficulty. To assist librarians with limited budgets, the AAAS has marked approximately 100 books with a double asterisk for those books considered indispensable, and some 200 books with a single asterisk for books recommended to be acquired as resources permit.

★ ★ ★

Two medical researchers have been awarded Nobel Prizes as the result of work done under grants from The National Foundation, which is supported by the New March of Dimes, Jan. 2–31.

March of Dimes Takes on Big New Health Task

Three major crippling diseases which are the targets of the New March of Dimes in 1960 affect one out of every four families in the United States, according to Basil O'Connor, president of The National Foundation.

He made the statement in describing progress by the March of Dimes organization since it announced its expanded program in research, patient aid and training of medical professionals 18 months ago.

"In addition to a continuing attack on polio, The National Foundation has laid the groundwork for a fight against birth defects and arthritis, two diseases that have left millions with painful disabilities," Mr. O'Connor said. "That's why the New March of Dimes has chosen 'Prevent Crippling Diseases!' as 1960's campaign theme."

Steps taken by The National Foundation in its enlarged program, one of the most ambitious ever undertaken by a voluntary health agency, include the following:

Birth Defects: Nine medical schools and hospitals and one state health department were awarded research grants in the first half of 1959 to study the causes of congenital malformations. With funds from the 1960 New March of Dimes, research in this field will be broadened to find a solution to this largest unmet childhood health problem. Patient aid will be offered to persons under 19 with certain defects of the skull and spine. Estimates are that 8,000 such victims may seek medical care each year.

Arthritis: In the first half of 1959 The National Foundation authorized research grants to eight hospitals, universities and medical centers for the study of causes and preventives of crippling arthritis. Included in these grants were three for arthritis evaluation centers in Rochester, N. Y., San Francisco and Dallas. A fourth center in New York City was awarded a similar grant last year. The primary aim of these evaluation centers is to study and devise new techniques of treatment and care for patients afflicted with this crippling disease. More than 11,000,000 Americans of all ages are estimated to be tortured by various kinds of arthritis and rheumatic diseases. An expanded patient aid program, supported by New March of Dimes funds, will offer financial assistance to persons under 19 suffering from rheumatoid arthritis.

Polio: Polio continued to be a major health problem in 1959. The number of cases rose sharply over 1958; paralytic cases rose even higher. More than 50,000 polio victims are currently on the patient aid rolls of The National Foundation. Though many of them were paralyzed in previous years, epidemics in 1958 and 1959 in such cities as Detroit, Kansas City and Des Moines added new thousands to the patient aid rolls. Some $16,500,000 in March of Dimes funds was spent in 1959 to defray medical costs for polio patients. Meanwhile, as of July 1, 1959, research in polio and related virus diseases was in progress in 43 scientific centers, including 16 respiratory and rehabilitation centers engaged in studying new techniques for the care and treatment of paralyed patients.

(*Continued on Pag 1,6*)

March of Dimes

(*Continued from Page 145*)

The National Foundation also expanded its professional training program to relieve the acute shortage of skilled experts needed to man the hospitals, clinics, research laboratories and medical training centers. A new Health Scholarship Program offering more than 500 scholarships a year is being offered to students in high schools or the first two years of college for training as doctors, nurses, physical therapists, occupational therapists and medical social workers.

The 1960 New March of Dimes, Jan. 2–31, will benefit one out of every four families in its broad program against birth defects, arthritis and polio, three major cripplers.

★ ★ ★

NBS Standard Materials Program

The National Bureau of Standards is now distributing 60,000 samples of standard materials a year to other laboratories for use in controlling chemical processes and in maintaining the accuracy of apparatus and equipment. A total of over 600 different standard materials are available from the Bureau—principally chemicals, ceramics, metals, ores, and radioactive nuclides. All are certified either for chemical composition or with respect to a specific physical or chemical property such as melting point, viscosity, or index of refraction. These standards make possible uniform measurements of heat and temperature, define the colors of paints, and calibrate instruments that control the composition of metals and motor fuels.

Within the past five years, requests from American science and industry have resulted in the issuance of about 70 new standard materials. Meanwhile, 150 new standard materials are being prepared for issuance through programs of careful analysis and precise measurement. Much of this expansion in the standard samples program has resulted from current efforts by government and industry to develop materials having specific properties for use at high temperatures or under other extreme conditions.

The standard samples program was established in 1905 when the American Foundrymen's Association turned over to the Bureau four sets of cast iron to be standardized for chemical composition. The majority of these chemical standards are metals and alloys, used extensively for monitoring the thousands of analyses made daily in industrial laboratories. Standards of chemical composition also serve as guides in developing new analytical methods for determining the composition of unknown materials. New chemical standards are prepared whenever an industrial need develops. Recent additions include high-temperature cobalt-nickel alloys for jet and missile production, titanium alloys for aircraft and ordnance research, zirconium alloys for nuclear-power development, lithium ores for the new lithium chemical industry, lead-tin bronzes for Navy defense purposes, and portland cement for the cement manufacturers.

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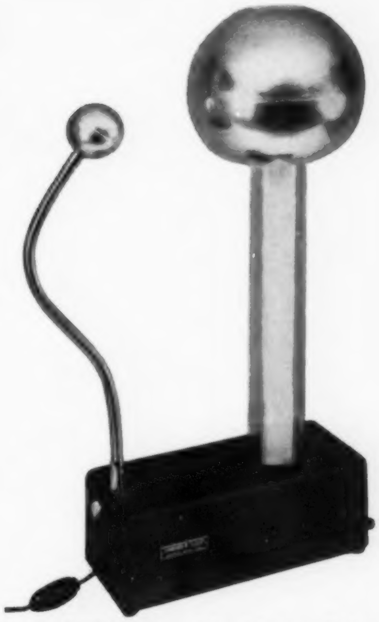
You Can Depend on the GENATRON

● THE MODERN ELECTROSTATIC GENERATOR

THE CAMBOSCO GENATRON serves not only for classical experiments in static electricity, but also for new and dramatic demonstrations that are not performable by any other means. It exemplifies a modern method of building up the tremendously high voltages required for atomic fission, for nuclear research, and for radiation therapy.

Entirely self-exciting, the GENATRON cracks into action at the snap of the switch --whose only function is that of starting the motor drive. No auxiliary charging method is employed. Hence, despite an output measured in hundreds of thousands of volts, no hazard is involved, for the operator or for the observers.



GENATRON, with Motor Drive

Operates on 110-volt A.C. or 110-volt D.C. Includes: Discharge Terminal, Lucite Insulating Cylinder, Latex Charge-Carrying Belt, Discharge Ball with Flexible Shaft, Accessory and Ground Jacks, Cast Metal Base with built-in Motor Drive, Connecting Cord, Plug, Switch, and Operating Instructions.

No. 61-705 .... $98.75

An Output of 250,000 Volts — or More!

THE CAMBOSCO GENATRON is designed to deliver, in normal operation, a discharge of the order of 250,000 volts. That figure, a conservative rating, is based on many trials conducted under average conditions. With ideal conditions, a potential difference of 400,000 volts has been achieved.

Modern Design - Sturdy construction and ever-dependable performance distinguish the GENATRON from all electrostatic devices hitherto available for demonstration work in Physics. This powerful, high-potential source, reflecting the benefits of extensive experience in electrostatic engineering, has absolutely nothing but purpose in common with the old fashioned static machine.

NO FRAGILE PARTS—Durability was a prime consideration in the design of the GENATRON which, with the exception of insulating members, is constructed entirely of metal.

The only part subject to deterioration is the charge-carying belt, which is readily replaceable.

NO TRANSFER BODIES—In all conventional influence machines, whether of Holtz or Wimshurst type, electrical charges are collected and conveyed (from rotating plates to electrodes) by a system of "transfer bodies." Such bodies have always taken the form of metal brushes, rods, button disk or segments—each of which, inevitably, permits leakage of the very charge it is intended to carry, and thereby sharply limits the maximum output voltage.

It is a distinguishing difference of the GENATRON that electrical charges, conveyed by a non-metallic material, are established **directly upon the discharge terminal.** The attainable voltage accordingly depends only upon the geometry of that terminal and the dielectric strength of the medium by which it is surrounded.

Unique Features of the CamboscO Genatron

DISCHARGE TERMINAL Charges accumulate on, and discharge takes place from, the outer surface of a polished metal "sphere"—or, more accurately, an oblate spheroid.

The upper hemisphere is flattened at the pole to afford a horizontal support for such static accessories as must be insulated from ground. A built-in jack, at the center of that horizontal area, accepts a standard banana plug. Connections may thus be made to accessories located at a distance from the GENATRON.

CHARGE-CARRYING BELT To the terminal, charges are conveyed by an endless band of pure, live latex — a CamboscO development which has none of the shortcomings inherent in a belt with an overlap joint.

DISCHARGE BALL High voltage demonstrations often require a "spark gap" whose width can be varied without immobilizing either of the operator's hands.

That problem is ingeniously solved in the GENATRON, by mounting the discharge ball on a flexible shaft, which maintains any shape into which it is bent. Thus the discharge ball may be positioned at any desired distance (over a sixteen-inch range) from the discharge terminal.

BASE...AND DRIVING MECHANISM Stability is assured by the massive, cast metal base—where deep sockets are provided for the flexible shaft which carries the discharge ball, and for the lucite cylinder which supports, and insulates, the discharge terminal.
The flat, top surface of the base (electrically speaking), represents the ground plane. Actual connection to ground is made through a conveniently located Jack-in-Head Binding Post. The base of the Genatron encloses, and electrically shields, the entire driving mechanism.

PRINCIPAL DIMENSIONS The overall height of the CamboscO GENATRON is 31 in. Diameters of Discharge Ball and Terminal are, respectively, 3 in. and 10 in. The base measures 5¼ x 7 x 14 in.

GENATRON, with Speed Control

Includes (in addition to equipment itemized above under No. 61-705) a built-in Rheostat, to facilitate demonstrations requiring less than the maxmium output.

No. 61-708 .... $19.00

No. 61-710 Endless Belt. Of pure latex. For replacement in No. 61-705 or No. 61-708 **$3.00**

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